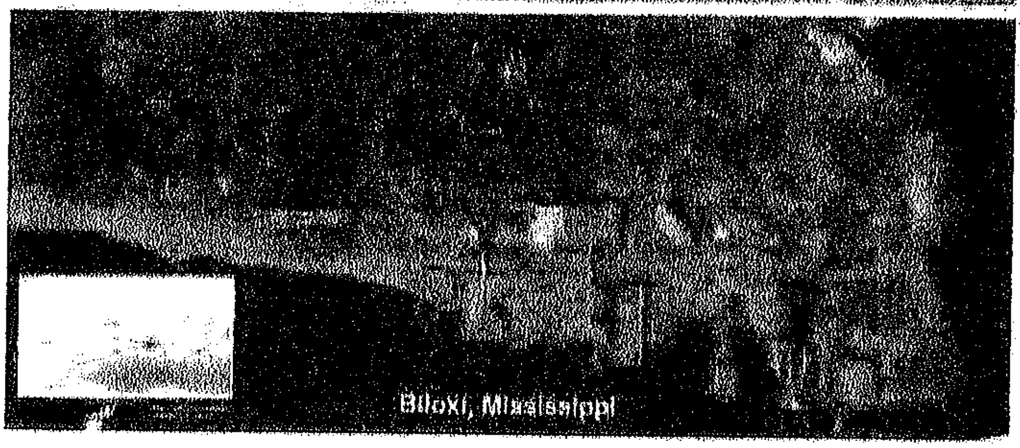


Additional Links

- CNN story quoting GRI's Dr. Fitzpatrick
- Hurricane expert, Dr. Fitzpatrick, probes Katrina's impact, prospect of more storms
- Dr. Fitzpatrick explains the 30-year cycle

GeoResources Institute, an ERC Affiliate • Director: David R. Shaw, Ph.D.
Ph: 662-325-9573 • Mississippi State, MS 39762 • WebMaster • Modified: October 12, 2005
Mississippi State University

SunHerald.com

Posted on Sun, Oct. 16, 2005

DOCUMENTING SURGE

Surveyors: Storm water topped at least 28 feet

Updated 100-year flood zone map is ultimate goal

By DON HAMMACK

dthammack@sunherald.com

The surveyors who've helped map Hurricane Katrina's storm surge continue to refine their data, but one thing seems certain.

Every suspicion that the storm was as bad as any we've ever seen is being confirmed.

On Scenic Drive in Pass Christian, there's a water mark inside a house that's been measured at roughly 28 feet. Two others in the neighborhood confirm it.

At Interstate 10's Jourdan River bridge in Hancock County, there's a debris line on the east end that's about 28 feet. Another mark at the Turkey Creek bridge in Gulfport shows the same surge.

At the Beach Mini Mart near the east end of the U.S. 90 bridge over Biloxi Bay, an inside mark measures 20 feet.

Along Interstate 10's Pascagoula River bridge, it's about 13 feet.

"The flood elevations are extraordinarily high," FEMA's Todd Davison said. "Anybody who has studied storm surge, these are well in excess of 100-year flood numbers."

FEMA spearheads compiling the

surveying data and hopes to release the first round of tabular data this week. A high-resolution online map should be available in mid-November.

The agency has already released suggestions to city officials on how to rebuild, making a first-cut prediction at what the ultimate goal of this project is, an updated 100-year flood zone map.

Working backward

The efforts to measure Katrina's storm surge are an effort in forensic meteorology. Think "CSI: Gulf Coast" with surveyors taking the place of coroners and investigators, plumb bobs, GPS units and spray paint instead of DNA kits, rubber gloves and toe tags.

Soon after the storm, teams from three government agencies hit the ground in South

Mississippi. Most of the information that's been released has come from the U.S. Geological Survey team's work along the I-10 corridor.

The Army Corps of Engineers' Mobile office hit east Jackson County, where it was easier to access with the I-10 bridge damage. FEMA contracted URS Corporation, a huge international engineering firm that's also involved in preparations to rebuild the U.S. 90 bridges, to go in and fill in the rest of the map.

A preliminary compilation of data shows 100 locations that have been measured, although less than a third have rough elevation numbers calculated.

Survey crews look at a variety of indicators to measure storm surge. Typically, they look inside buildings because waves don't blur the true height of the surge.

"If it was inside somebody's home, they didn't want to go in there and spray paint the walls," said Mickey Plunkett of the Jackson USGS office, "so they'd get a surveying instrument inside and tie it to a fire hydrant or wheel curb outside."

Katrina has caused extra difficulties because many benchmarks used in surveying were washed away or damaged. The USGS crews, for example, used the surface of the I-10 bridges, which are known heights from the state transportation department, to measure from.

Computer simulations help

Trying to figure out exactly what happens during a storm is difficult. It's up to computer modeling to take a look at what happened.

"The reason we run the computer simulations is the observations break down," said Pat Fitzpatrick, Mississippi State University's GeoResources Institute hurricane expert. "The tide gauges are all destroyed by the storm."

The GRI has run models for Katrina showing the storm's impact in motion. It and LSU are the only schools that run the Advanced Circulation Model, according to Fitzpatrick.

He says it's better than the National Weather Services model, using parallel computing power to examine small chunks of water that can model bayous, canals and coastal contours better.

The two models use the same equations, inputting wind data from the National Hurricane Center, hurricane eye size, the breadth of hurricane- and tropical storm-force winds and speed of movement.

The most accurate simulation takes into account the tides, but takes several weeks to run. The simulations done for Katrina were done without, creating a 2- to 3-foot error in an area that doesn't feature a wide range of tides.

In the Mississippi simulation, Waveland starts taking on water on Aug. 29 at 5 a.m., with

water moving up the Jourdan River. Three hours later, water is 12 to 15 feet high in Waveland and areas around Biloxi are starting to flood.

At 11 a.m., there are dramatic differences. Water is five miles inland west of Bay St. Louis, at 27 to 33 feet. The rest of the Mississippi Coast has major inundation with surge heights of 18 to 24 feet.

Fitzpatrick's team also ran simulations on Louisiana, which yielded interesting results. He doesn't think Lake Pontchartrain got high enough to overflow its levees into New Orleans.

Instead, the computer results imply that there was a structural failure in those levees.

What happens now?

Mapping all the real-world data continues, and it will do so for quite some time. FEMA will release a series of maps like it did after Ivan hit Alabama and the Florida Panhandle (www. fema.gov/ivanmaps).

They will start with the mid-November maps. Eventually, there will be very interactive products online, with links to photos of actual locations where the measurements were taken.

But the ultimate goal of the effort is a revision of the 100-year, or one-percent flood maps used by the insurance and financial industry to set rates and determine where money should be loaned to rebuild.

The advisory information that went out is the first step in that.

"If you're a good driver, you get better rates. If you're not a smoker, you get better rates," he said. "Floods are the same. People who use the advisory information will get better rates."

Katrina's massive storm surge will change the way South Mississippi thinks about storms. It'll do so beyond the psychological impact she's brought to the area, in more concrete ways like this flood map.

Davison said that it won't strictly reflect Katrina. Experts think it's beyond the pale of a 100-year event.

Instead, it will take into account the 25 years or so since the last revision that have changed the historical basis for the maps, storms like Elena, Opal, Ivan and Dennis.

"It's fair to say the 100-year is going to go up," Davison said, "but they won't go to the Katrina levels."

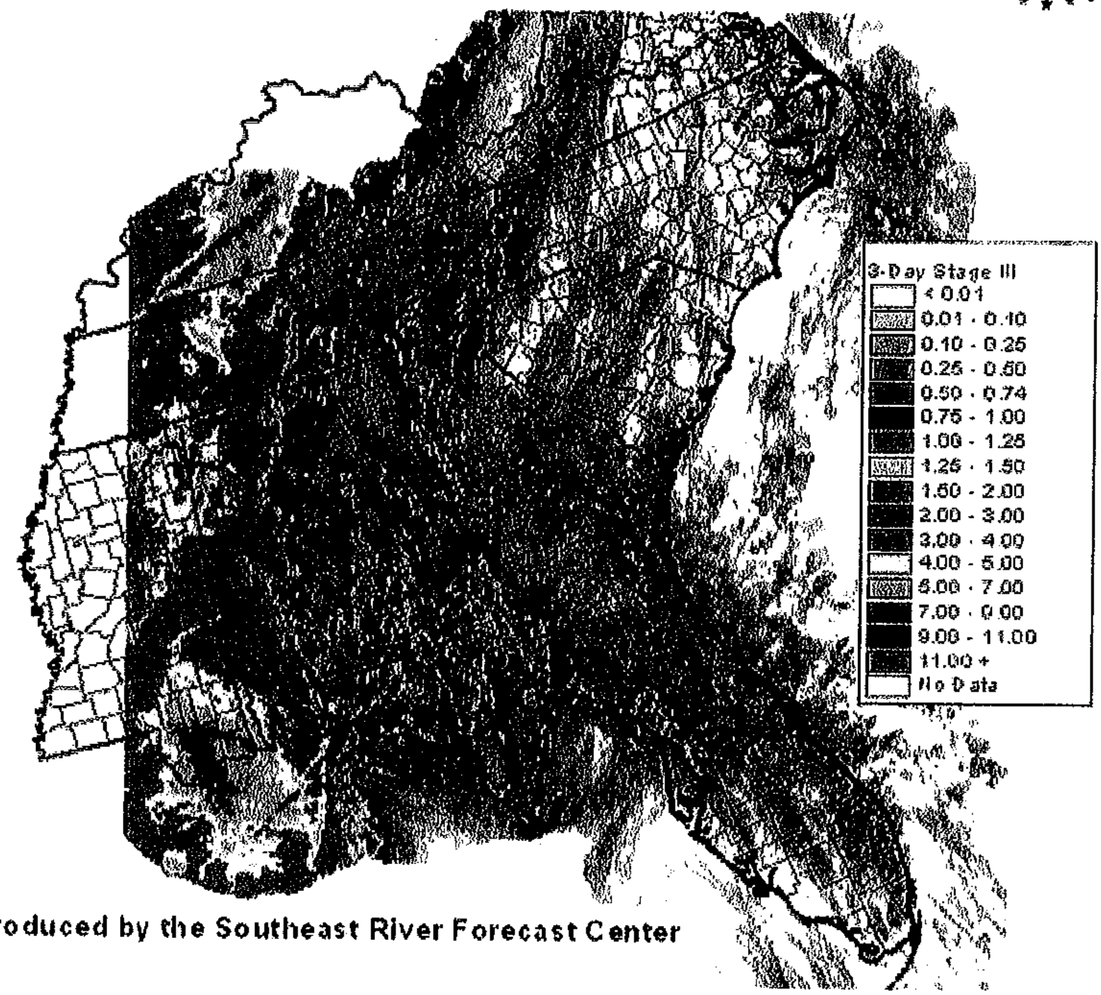
Don Hammack can be reached at 896-2326.

National Oceanic and Atmospheric Administration

National Weather Service

3-Day Radar-Derived Precipitation Estimates

8 AM. 8/28/2005 thru 8 AM. 8/31/2005 Eastern



Produced by the Southeast River Forecast Center

Climate of 2005
Summary of Hurricane Katrina

National Climatic Data Center,
Last updated - September 1st, 2005

Hurricane Katrina

Overview / Storm Meteorology and Background / Rain, wind and pressure / Impacts of the Storm

Overview

Hurricane Katrina was one of the strongest storms to impact the coast of the United States during the last 100 years. With sustained winds during landfall of 140 mph (a strong category 4 hurricane on the Saffir-Simpson scale) and minimum central pressure the third lowest on record at landfall (920 mb), Katrina caused widespread devastation along the central Gulf Coast states of the US. Cities such as New Orleans, LA, Mobile, AL, and Gulfport, MS bore the brunt of Katrina's force and will need weeks and months of recovery efforts to restore normality.

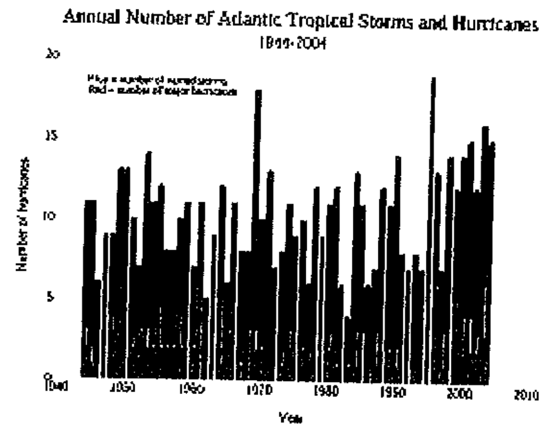
Other storms have had stronger sustained winds when they made landfall including the following:

The Labor Day Hurricane, Florida Keys, September 2, 1935, Category 5, 892 mb, Approaching 200 mph
Hurricane Camille, Mississippi, August 17, 1969, Category 5, 909 mb, Approaching 190 mph
Hurricane Andrew, Southeast Florida, August 24, 1992, Category 5, 922 mb, 165 mph
Hurricane Charley, Punta Gorda, Florida, August 13, 2004, Category 4, 941 mb, 150 mph

The most deadly hurricane to strike the U.S. made landfall in Galveston, Texas on September 8, 1900. This was also the greatest natural disaster to ever strike the U.S., claiming more than 8000 lives when the storm surge caught the residents of this island city

by surprise.

As shown in the figures to the right, tropical cyclone activity in the Atlantic basin has been above normal since 1995. This has been largely in response to the active phase of the multi-decadal signal. The average number of named storms since 1995 has been 13, compared to 8.6 during the preceding 25 years during which time the multi-decadal signal was in an inactive phase. An average of 7.7 hurricanes and 3.6 major hurricanes since 1995 compares to 5 hurricanes and 1.5 major hurricanes from 1970-1994.



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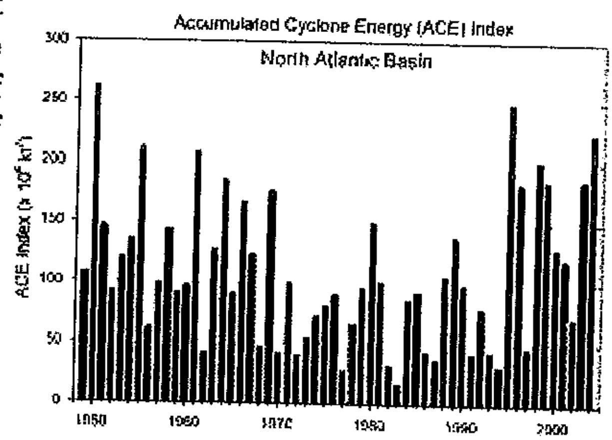
Characteristics of an active multi-decadal signal in the Atlantic include: warmer SSTs in the tropical Atlantic region, an amplified sub-tropical ridge at upper levels across the central and eastern North Atlantic, reduced vertical wind shear in the deep tropics over the central North Atlantic, and an African Easterly Jet (AEJ) that is favorable for promoting the development and intensification of tropical disturbances moving westward off the coast of Africa. Recent studies also indicate that in addition to this multi-decadal oscillation the destructive power of hurricanes has generally increased since the mid-1970s, when the period of the most rapid increase in global ocean and land temperatures began.



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However, it is important to note that increased tropical cyclone activity does not necessarily translate into an increase in the number of landfalling tropical storms or hurricanes. Six of the past 11 years have had one or fewer landfalling hurricanes along the Gulf Coast, and there

is no long-term trend in the number of landfalling hurricanes since 1900.

Below is a synopsis of the conditions that produced historic Hurricane Katrina, as well as some information of rain and wind records and a very preliminary description of the major impacts. Note that reports are constantly being updated as a result of new information, and this page will be updated during the next month as new reports and data become available.

Meteorology

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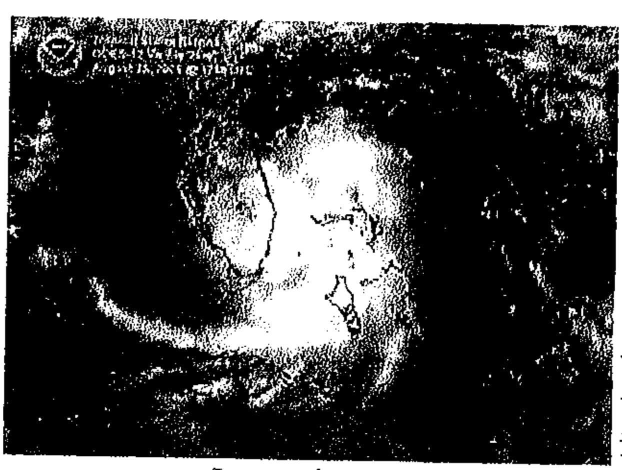

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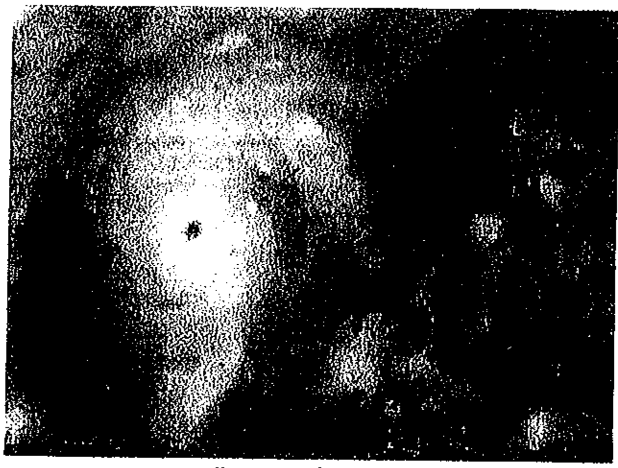
Hurricane Katrina developed initially as a tropical depression (TD #12 of the season) in the southeastern Bahamas on August 23rd. This tropical depression strengthened into Tropical Storm Katrina the next day. It then moved slowly along a northwesterly then westerly track through the Bahamas, increasing in strength during this time. A few hours before landfall in south Florida at around 6.30 EDT on August 25th, Katrina strengthened to become a category 1 (windspeeds of 75mph or greater) hurricane. Landfall occurred between Hallandale Beach and North Miami Beach, Florida, with windspeeds of approximately 80 mph. Gusts of above 90 mph were measured as Katrina came ashore. As the storm moved southwest across the tip of the Florida peninsula, Katrina's winds decreased slightly before regaining hurricane strength in the Gulf of Mexico. Given that Katrina spent only seven hours over land, its strength was not significantly diminished and it quickly re-intensified shortly after moving over the warm waters of the Gulf.

Katrina moved almost due westward after entering the Gulf of Mexico. A mid-level ridge centered over Texas weakened and moved westward allowing Katrina to gradually turn to the northwest and then north into the weakness in the ridging over the days that followed. Atmospheric and sea-surface conditions (an upper level anticyclone over the Gulf and warm



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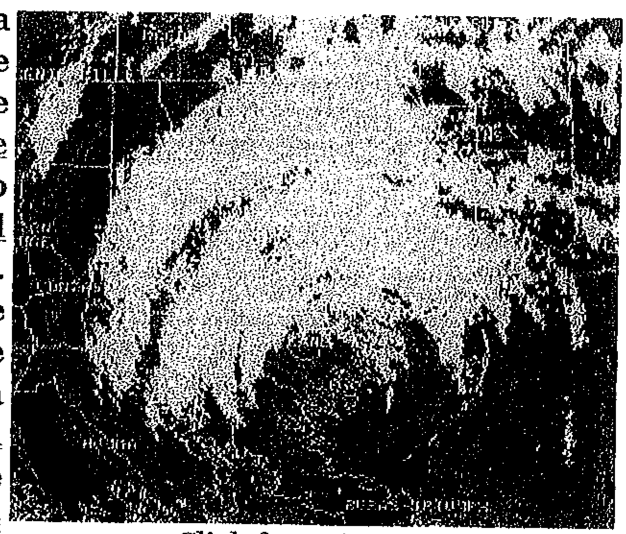
SSTs) were conducive to cyclone's rapid intensification, which lead to Katrina attaining 'major hurricane' status on the afternoon of the 26th.

Continuing to strengthen and move northwards during the next 48 hours, Katrina reached maximum windspeeds on the morning of Sunday August 28th of 150 kts (category 5), and its minimum central pressure dropped that afternoon to 902 mb - the 4th lowest on record for an Atlantic storm. Although Katrina, at its peak strength was comparable to Camille's intensity, it was a significantly larger storm and impacted a broader area of the Gulf coast.

Although tropical cyclones of category 5 strength are rarely sustained for long durations (due to internal dynamics), Katrina remained a strong category 4 strength hurricane despite the entrainment of dryer air and an opening of the eyewall to the south and southwest before landfall on the morning of the 29th (go to NCDC's NEXRAD viewer site for additional radar imagery and animations of Katrina). Landfalling windspeeds at Grand Isle, LA were approximately 140 mph with a central pressure of 920mb - the 3rd lowest on record for a landfalling Atlantic storm in the US. Rainfall amounts for Louisiana and along the Gulf are described below along with other impacts of the storms.



Click for animation

Rain, wind, storm surge

Eastern Florida:

During its initial landfall in southern Florida, Katrina generated over 5 inches of rainfall across a large area of southeastern Florida. An analysis by NOAA's Climate Prediction Center shows that parts of the region received heavy rainfall, over 15 inches in some locations, which caused localized flooding.

Winds at landfall north of Miami were 80 mph (category 1 strength), leading to some damage and extensive power outages.

Gulf Coast:
Rainfall from Katrina's outer bands began affecting the Gulf coast well before landfall. As Katrina came ashore on August 29th, rainfall exceeded rates of 1 inch/hour across a large area of the coast. NOAA's Climate Reference Network Station in Newton, MS (60 miles east of Jackson, MS) measured rainfall rates of over an inch an hour for 3 consecutive hours, with rates of over 0.5 in/hr for 5 hours during August 29th. Precipitation analysis from NOAA's Climate Prediction Center show that rainfall accumulations exceeded 8-10 inches along much of the hurricane's path and to the east of the track.

Windspeeds over 140 mph were recorded at landfall in southeastern Louisiana while winds gusted to over 100 mph in New Orleans, just west of the eye. As the hurricane made its second landfall on the Mississippi/Louisiana border, windspeeds were approximately 110 kts (125 mph). Gusts of over 80mph were recorded in Mobile and 90 mph in Biloxi, MS.

The central pressure at landfall was 920 mb, which ranked 3rd lowest on record for US-landfalling storms behind Camille (909 mb) and the Labor Day hurricane that struck the Florida Keys in 1935 (892 mb). Hurricane Andrew in 1992 dropped to fourth, as its central pressure was 922 mb at landfall. Katrina also reached a minimum central pressure of 902 mb at its peak, ranking 4th lowest on record for all Atlantic basin hurricanes.

Inland:
As the storm moved inland and weakened to a tropical storm on the 29th, rainfall became the primary impact. Rainfall amounts exceeded 2-4 inches across a large area from the Gulf coast to the Ohio Valley. As a result, flood watches and warnings were common across these regions. Rain bands from Katrina also produced tornadoes causing further damage in areas such as Georgia.

Impacts

LOSS OF LIFE: From the Gulf states (principally Louisiana and Mississippi), the loss of life is unknown but will likely reach well into the hundreds and possibly higher. It is clearly one of the most devastating natural disasters in recent US history. From Katrina's first landfall in Florida, while it was at category one strength, initial estimates suggest 11 deaths resulted.

FLOODING: The loss of life and property damage was worsened by breaks in the levees

that separate New Orleans from surrounding lakes. At least 80% of New Orleans was under flood water on August 31st, largely as a result of levee failures from Lake Pontchartrain. The combination of strong winds, heavy rainfall and storm surge led to breaks in the earthen levee after the storm passed, leaving some parts of New Orleans under 20 feet of water. Storm surge from Mobile Bay led to inundation of Mobile, Alabama causing imposition of a dusk-to-dawn curfew for the City. Large portions of Biloxi and Gulfport, Mississippi were underwater as a result of a 20 to 30+ foot storm surge which flooded the cities.

OIL INDUSTRY: A major economic impact for the nation was the disruption to the oil industry from Katrina. Preliminary estimates from the Mineral Management Service suggest that oil production in the Gulf of Mexico was reduced by 1.4 million barrels per day (or 95 % of the daily Gulf of Mexico production) as a result of the hurricane. Gasoline had reached a record high price/gallon as of Monday August 30th with concerns over refinery capacity apparently driving the increase. More information is available from a Department of Energy report.

POWER OUTAGES: Over 1.7 million people lost power as a result of the storm in the Gulf states, with power companies estimating that it will take more than several weeks to restore power to some locations. Drinking water was also unavailable in New Orleans due to a broken water main that serves the city. Power was lost to 1.3 million customers in southeastern Florida from the initial landfall on August 24th.

COST: Estimates for insured damages for Hurricane Katrina are still extremely preliminary and properly assessing losses will take weeks or months. However, the cost of Katrina will certainly be a minimum of several billion dollars and might exceed losses from Hurricane Andrew. Andrew caused $15.5 billion in insured damage in 1992. Adjusted for inflation, Andrew resulted in more than $25 billion in insured damage.

TRAVEL: Both of New Orleans' airports were flooded and closed on August 30th and bridges of Interstate 10 leading east out of the city were destroyed. Most of the coastal highways along the Gulf were impassable in places and most minor roads near the shore were still underwater or covered in debris as of August 30th. Katrina also disrupted travel as it headed inland, with more than 2 inches of rain falling across a large area from the coast to parts of Ohio during the 48 hours after Katrina made landfall.

Useful Links

- NCDC's Tropical Cyclone Overview Page

- Space Science and Engineering Center Hurricane Katrina Page
- The National Weather Service **(click on the map to take you to local homepages)**
- NOAA's National Hurricane Center
- NOAA's Climate Prediction Center

Questions?

For all climate questions other than questions concerning this report, please contact the National Climatic Data Center's Climate Services Division:

Climate Services Division
NOAA/National Climatic Data Center
151 Patton Avenue
Asheville, NC 28801-5001
fax: 828-271-4876
phone: 828-271-4800
email: questions@ncdc.noaa.gov

For further information on the historical climate perspective presented in this report, contact:

Jay Lawrimore
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151 Patton Avenue
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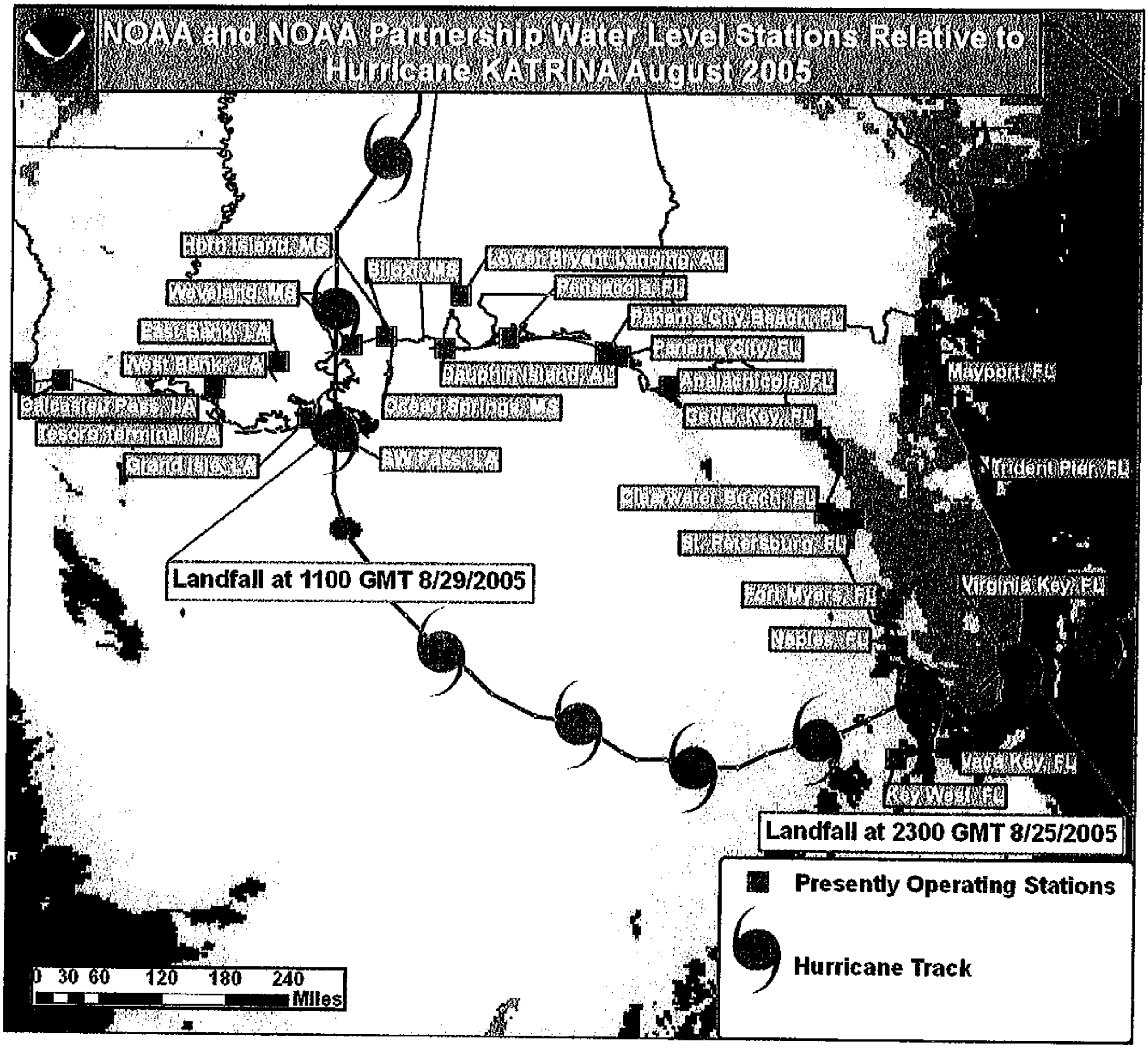
email: Jay.Lawrimore@noaa.gov

PRELIMINARY REPORT

HURRICANE KATRINA STORM TIDE SUMMARY



SUMMARY

Hurricane KATRINA made the first landfall on **August 25th at 2300 GMT**, between Hallandale Beach and North Miami Beach, FL, and continued into the Gulf of Mexico (Coverpage). KATRINA increased in strength and curved northward, making the second landfall on **August 29th at 1100 GMT**, at Grand Isle, LA. At the time of first landfall, water levels were near predictions at stations along eastern Florida (Figures 2-5). Water levels elevated after KATRINA had passed, on August 26th (Tables 1 & 2). At the time of the second landfall, KATRINA'S maximum sustained winds were between **135 - 145 mph,** with higher gusts. The minimum barometric pressures were between **918-923 mb.** The Center for Operational Oceanographic Products and Services (CO-OPS) stations recorded elevated water levels, primarily from Calcasieu Pass, LA to Apalachicola, FL (Figure 1-25). However, elevated water levels were also observed in Texas and along the Gulf coast of Florida (Tables 1 & 2). Station location information is in Appendix 1.

Ocean Springs, MS, recorded the highest observed water levels, at **4.043 m (13.26 ft)** above MLLW. However, the sensor ceased transmissions at this point and did not record a maximum elevation (Table 1; Figure 14). Sensor transmission failure also occurred at the next highest observed water level station, Waveland, MS **(2.737 m, 8.98 ft; Figure 15)**. Pilots Station, SW Pass, LA **(2.362 m, 7.75 ft; Figure 20)** and Pensacola, FL **(2.038 m, 6.69 ft; Figure 11)** had the next highest observed water levels, respectively.

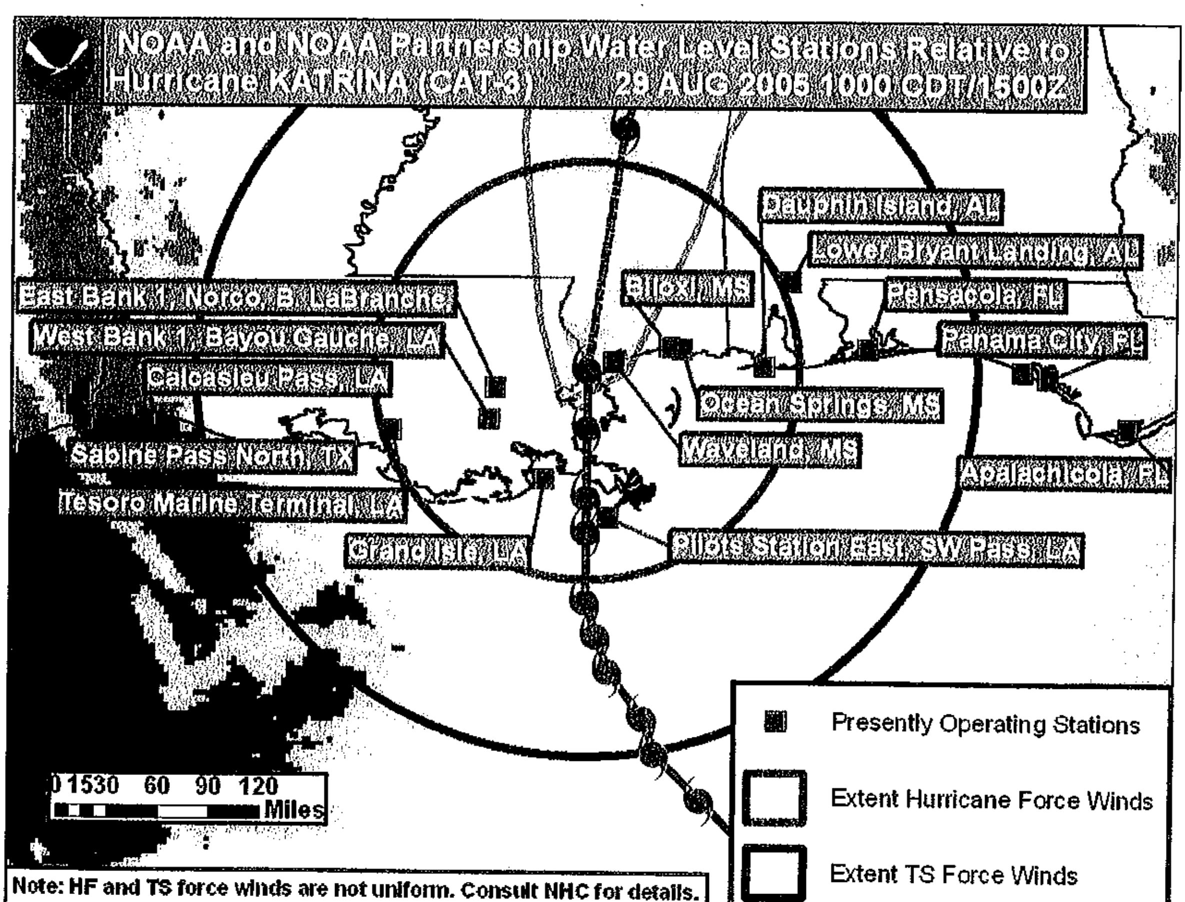


Figure 1: Map illustrating the locations of stations which recorded the highest observed water levels, primarily from Calcasieu Pass, LA to Apalachicola, FL.

Table 1: **Maximum water levels** for Hurricane KATRINA, August 2005. All preliminary data is subject to NOS verification.

Station Name	Station ID	Date & Time GMT	Max Water Level (Meters above MLLW)	Predicted Water Levels (m)	Difference (m)	Max Water Level (Feet above MLLW)	Predicted Water Levels (ft)	Difference (ft)
[1]Ocean Springs, MS	8743281	08-29-05 13:18	4.043	0.509	3.534	13.26	1.67	11.59
[1]Waveland, MS	8747766	08-29-05 09:12	2.737	0.504	2.233	8.98	1.65	7.33
Pilots Station, SW Pass, LA	8760922	08-29-05 09:30	2.362	0.482	1.880	7.75	1.58	6.17
Pensacola, FL	8729840	08-29-05 15:24	2.038	0.459	1.579	6.69	1.51	5.18
Dauphin Island , AL	8735180	08-29-05 17:00	1.942	0.297	1.645	6.37	0.97	5.40
[1]Horn Island, MS	8742221	08-29-05 04:48	1.898	0.262	1.636	6.23	0.86	5.37
[2]Grand Isle, LA	8761724	08-29-05 12:42	1.739	0.442	1.297	5.71	1.45	4.26
Cedar Key, FL	8727520	08-28-05 13:30	1.659	1.089	0.570	5.44	3.57	1.87
Trident Pier, FL	8721604	08-26-05 17:48	1.500	1.209	0.291	4.92	3.97	0.95
Apalachicola, FL	8728690	08-28-05 14:12	1.357	0.555	0.802	4.45	1.82	2.63
Panama City Beach, FL	8729210	08-29-05 12:36	1.323	0.528	0.795	4.34	1.73	2.61
[1]Biloxi, MS	8744117	08-29-05 07:42	1.316	0.443	0.873	4.32	1.45	2.86
Clearwater Beach, FL	8726724	08-28-05 09:12	1.307	0.822	0.485	4.29	2.70	1.59
[2]Lower Bryant Landing, AL	8737373	08-29-05 14:06	1.186	0.582	0.604	3.89	1.91	1.98
Panama City, FL	8729108	08-29-05 13:54	1.168	0.484	0.684	3.83	1.59	2.24
Virginia Key, FL	8723214	08-26-05 06:24	0.979	0.670	0.309	3.21	2.20	1.01
Calcasieu, LA	8768094	08-29-05 07:18	0.938	0.684	0.254	3.08	2.24	0.83
Galveston Bay Entrance, TX	8771341	08-29-05 06:42	0.892	0.551	0.341	2.93	1.81	1.12
Vaca Key, FL	8723970	08-26-05 08:48	0.769	0.335	0.434	2.52	1.10	1.42
Sabine, TX	8770570	08-29-05 08:06	0.759	0.575	0.184	2.49	1.89	0.60
[2]East Bank, LaBranche, LA	8762372	08-29-05 06:18	0.712	0.033	0.679	2.34	0.11	2.23
Key West, FL	8724580	08-26-05 07:00	0.694	0.609	0.085	2.28	2.00	0.28
Bayou Gauche, LA	8762482	08-29-05 15:36	0.482	0.042	0.440	1.58	0.14	1.44
Tesoro Terminal, LA	8764044	08-30-05 11:12	0.305	0.184	0.121	1.00	0.60	0.40

[1] Sensor ceased transmissions and did not record maximum water level.
[2] Sensor malfunction noted at elevated water levels.

Table 2: **Maximum water levels in geographic order** for Hurricane KATRINA, August 2005. All preliminary data is subject to NOS verification.

Station Name	**Station ID**	**Date & Time** GMT	**Max Water Level** (Meters above MLLW)	**Predicted Water Levels** (m)	**Difference** (m)	**Max Water Level** (Feet above MLLW)	**Predicted Water Levels** (ft)	**Difference** (ft)
Trident Pier, FL	8721604	08-26-05 17:48	1.500	1.209	0.291	4.92	3.97	0.95
Virginia Key, FL	8723214	08-26-05 06:24	0.979	0.670	0.309	3.21	2.20	1.01
Vaca Key, FL	8723970	08-26-05 08:48	0.769	0.335	0.434	2.52	1.10	1.42
Key West, FL	8724580	08-26-05 07:00	0.694	0.609	0.085	2.28	2.00	0.28
Clearwater Beach, FL	8726724	08-28-05 09:12	1.307	0.822	0.485	4.29	2.70	1.59
Cedar Key, FL	8727520	08-28-05 13:30	1.659	1.089	0.570	5.44	3.57	1.87
Apalachicola, FL	8728690	08-28-05 14:12	1.357	0.555	0.802	4.45	1.82	2.63
Panama City, FL	8729108	08-29-05 13:54	1.168	0.484	0.684	3.83	1.59	2.24
Panama City Beach, FL	8729210	08-29-05 12:36	1.323	0.528	0.795	4.34	1.73	2.61
Pensacola, FL	8729840	08-29-05 15:24	2.038	0.459	1.579	6.69	1.51	5.18
[2]Lower Bryant Landing, AL	8737373	08-29-05 14:06	1.186	0.582	0.604	3.89	1.91	1.98
[2]Dauphin Island , AL	8735180	08-29-05 17:00	1.942	0.297	1.645	6.37	0.97	5.40
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Tesoro Terminal, LA	8764044	08-30-05 11:12	0.305	0.184	0.121	1.00	0.60	0.40
Calcasieu, LA	8768094	08-29-05 07:18	0.938	0.684	0.254	3.08	2.24	0.83
Sabine, TX	8770570	08-29-05 08:06	0.759	0.575	0.184	2.49	1.89	0.60
Galveston Bay Entrance, TX	8771341	08-29-05 06:42	0.892	0.551	0.341	2.93	1.81	1.12

[1] Sensor ceased transmissions and did not record maximum water level.
[2] Sensor malfunction noted at elevated water levels.

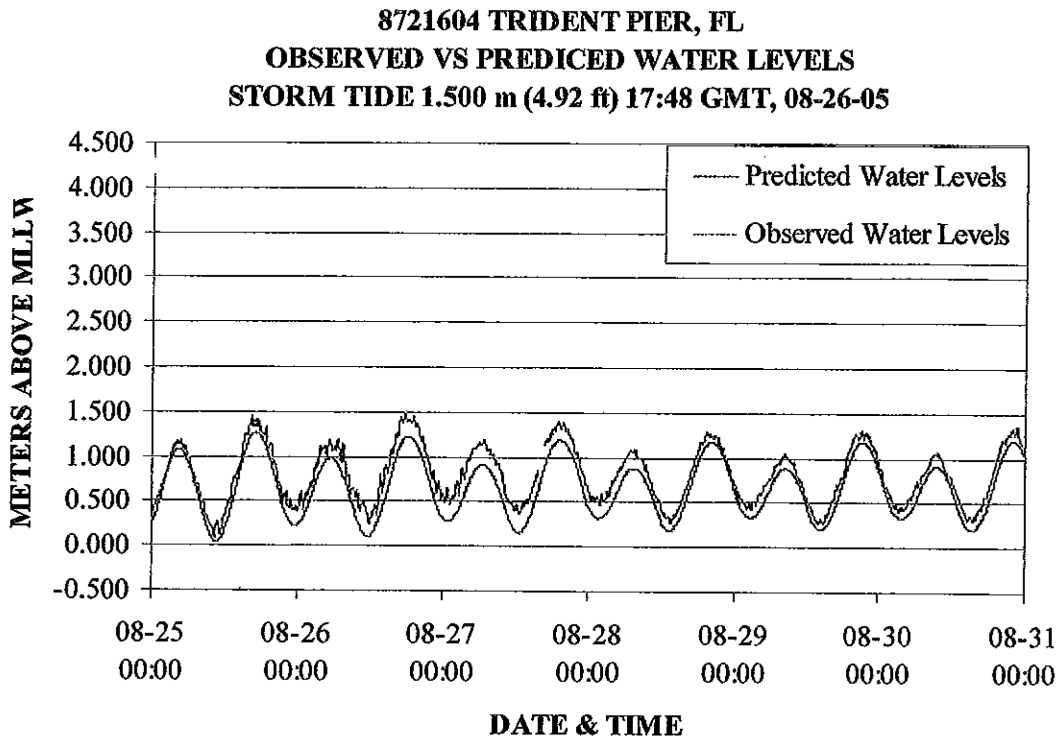


Figure 2: Time series of observed and predicted water levels at Trident Pier, FL, before, during, and after Hurricane KATRINA.

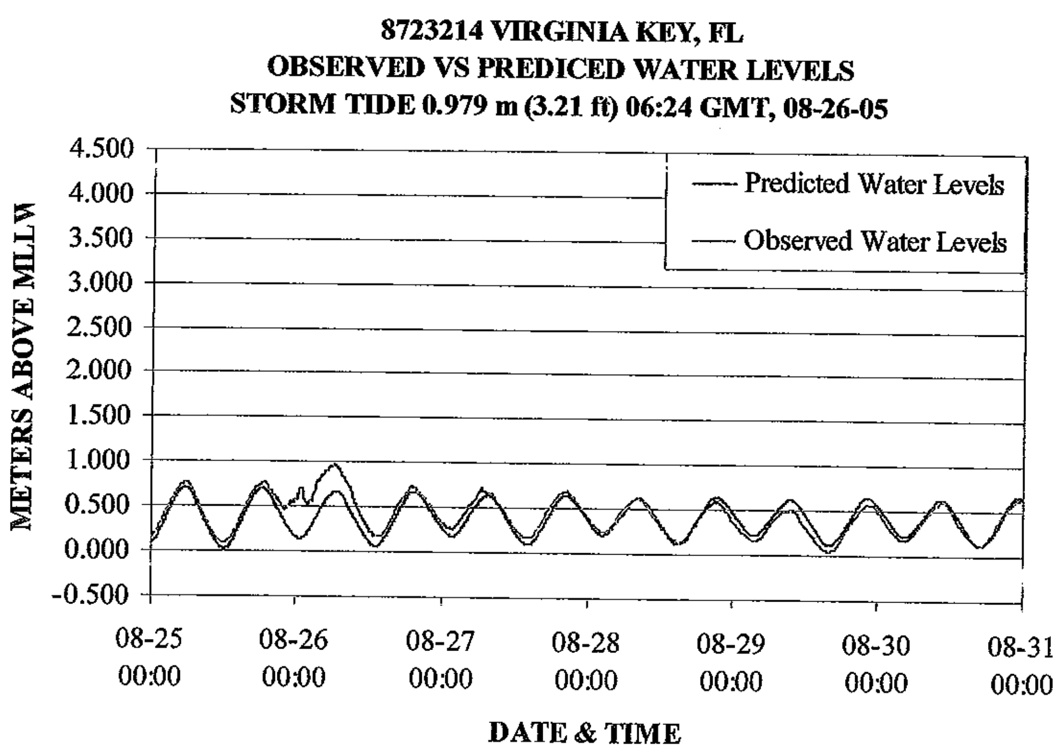


Figure 3: Time series of observed and predicted water levels at Virginia Key, FL, before, during, and after Hurricane KATRINA.

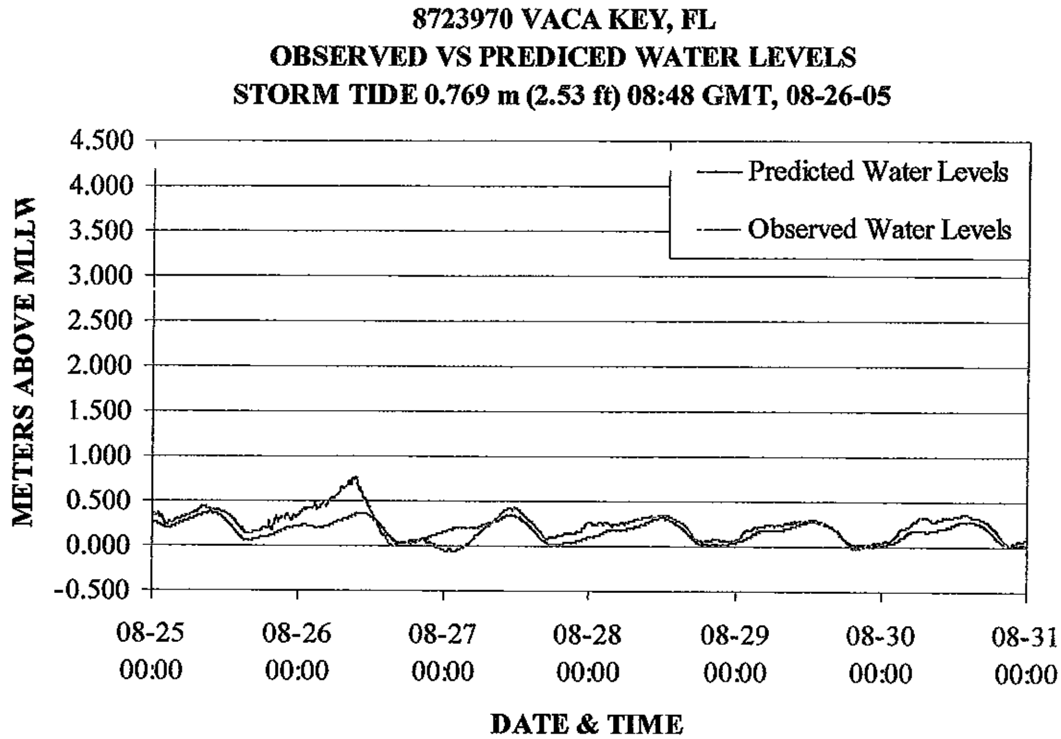


Figure 4: Time series of observed and predicted water levels at Vaca Key, FL, before, during, and after Hurricane KATRINA.

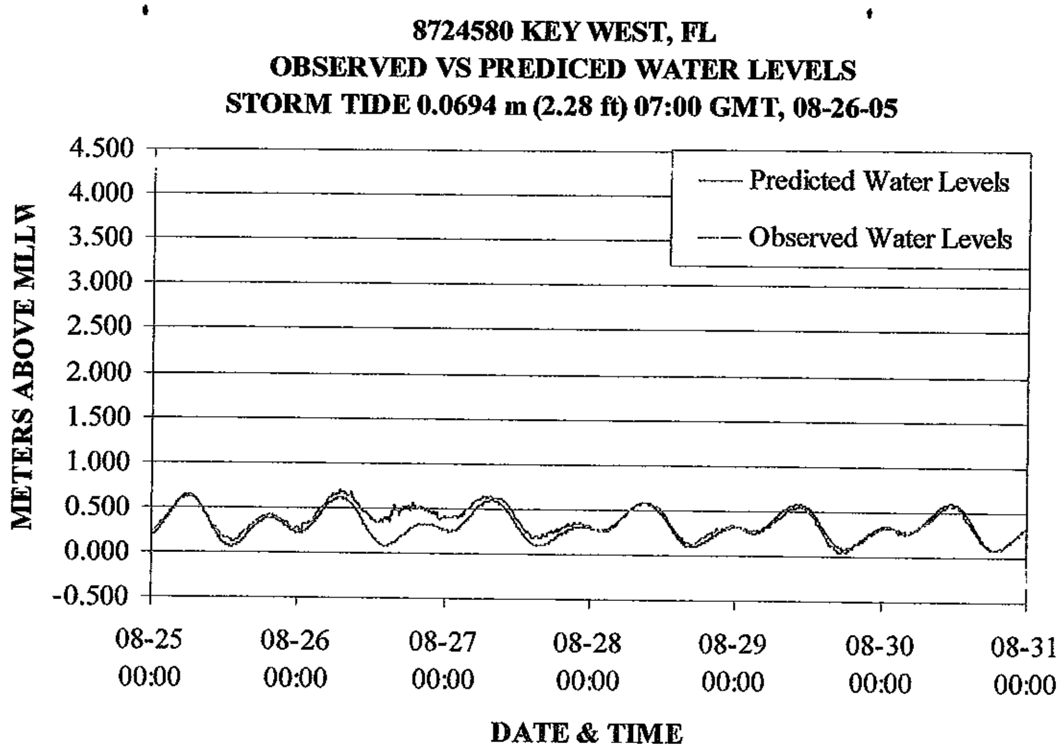


Figure 5: Time series of observed and predicted water levels at Key West, FL, before, during, and after Hurricane KATRINA.

8726724 CLEARWATER
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 1.307 m (4.29 ft) 09:12 GMT, 08-28-05

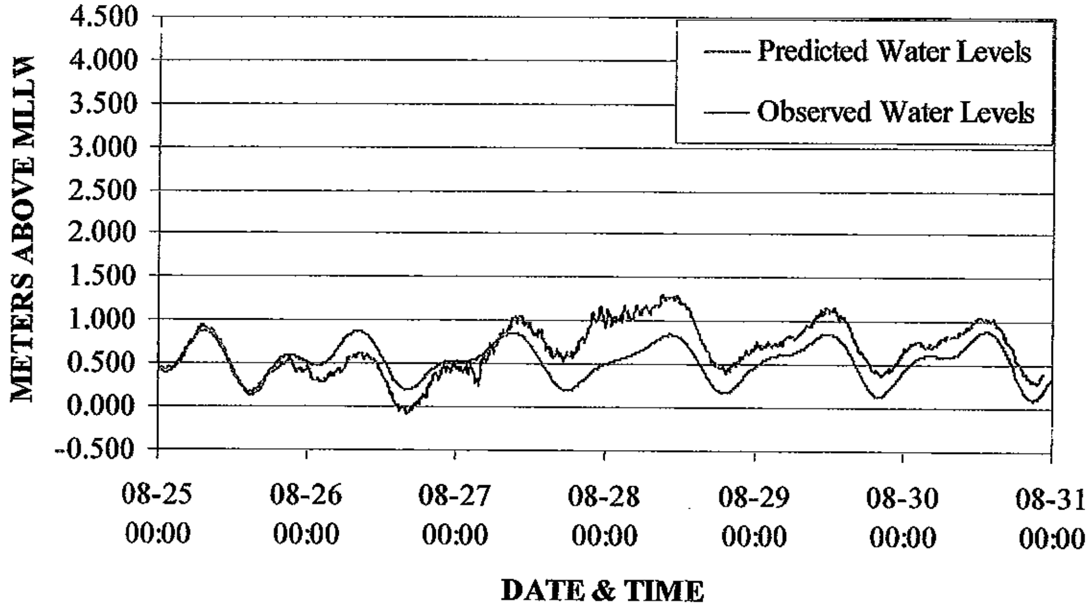


Figure 6: Time series of observed and predicted water levels at Clearwater, FL, before, during, and after Hurricane KATRINA.

8727520 CEDAR KEY, FL
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 1.659 m (5.44 ft) 13:30 GMT, 08-28-05

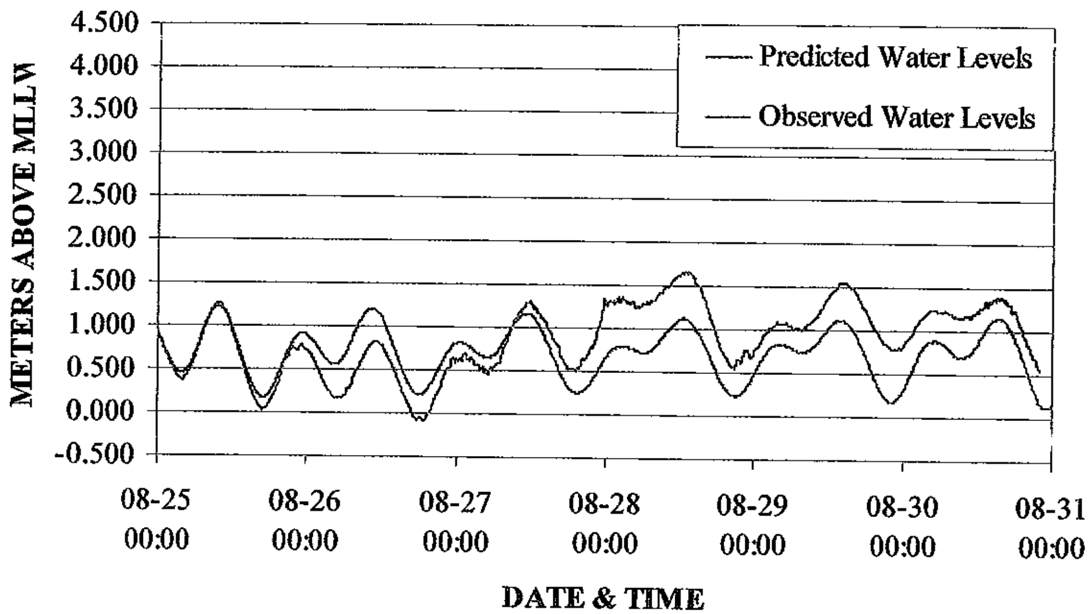


Figure 7: Time series of observed and predicted water levels at Cedar Key, FL, before, during, and after Hurricane KATRINA.

8728690 APALACHICOLA, FL
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 1.357 m (4.45 ft) 14:12 GMT, 08-28-05

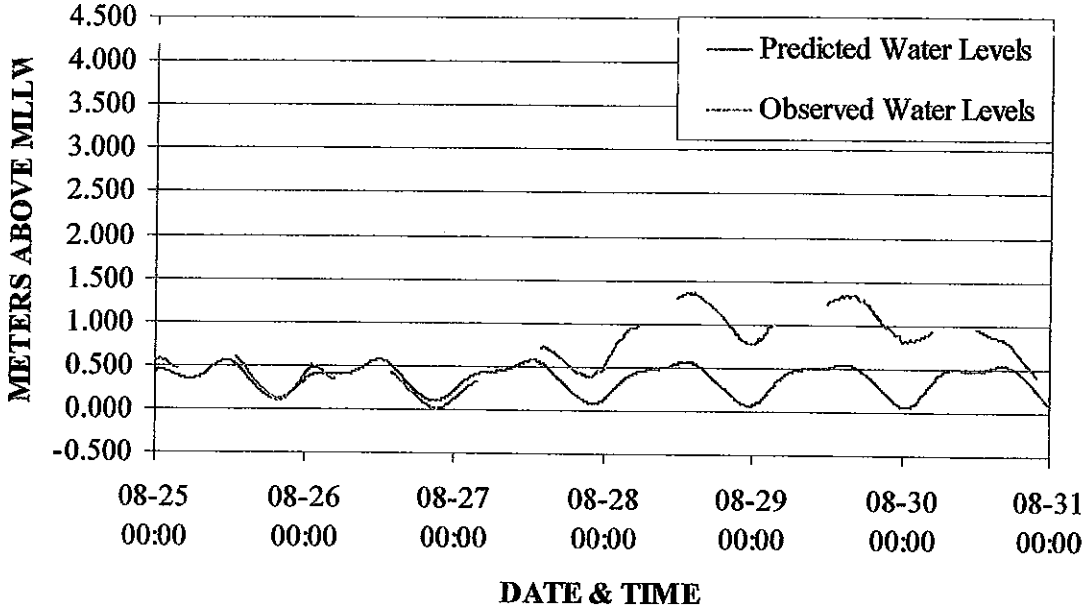


Figure 8: Time series of observed and predicted water levels at Apalachicola, FL, before, during, and after Hurricane KATRINA.

8729108 PANAMA CITY, FL
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 1.168 m (3.83 ft) 13:54 GMT, 08-29-05

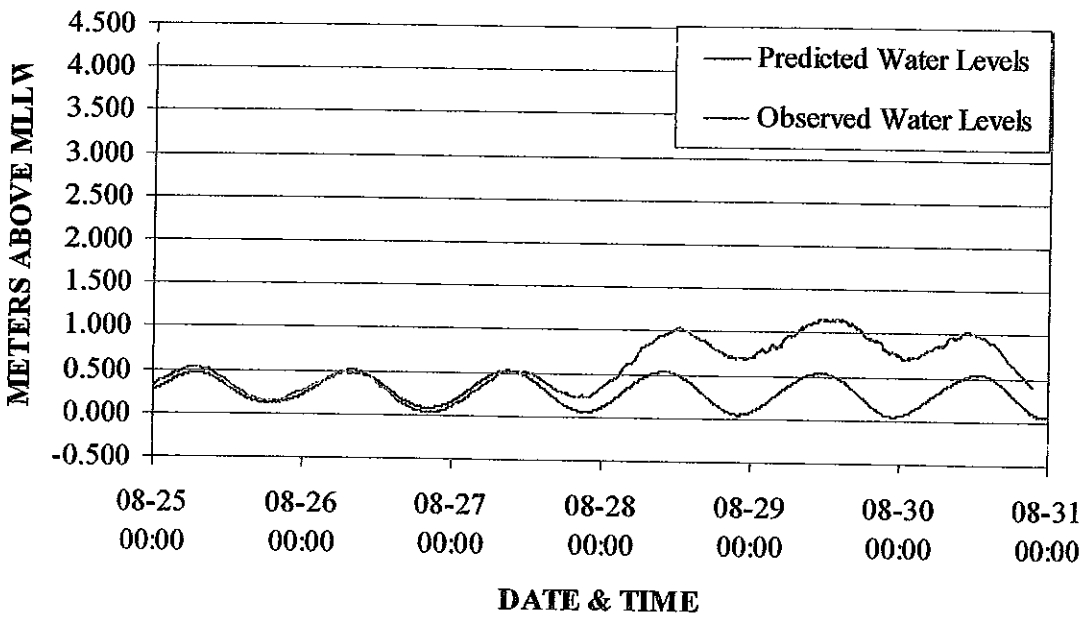


Figure 9: Time series of observed and predicted water levels at Panama City, FL, before, during, and after Hurricane KATRINA.

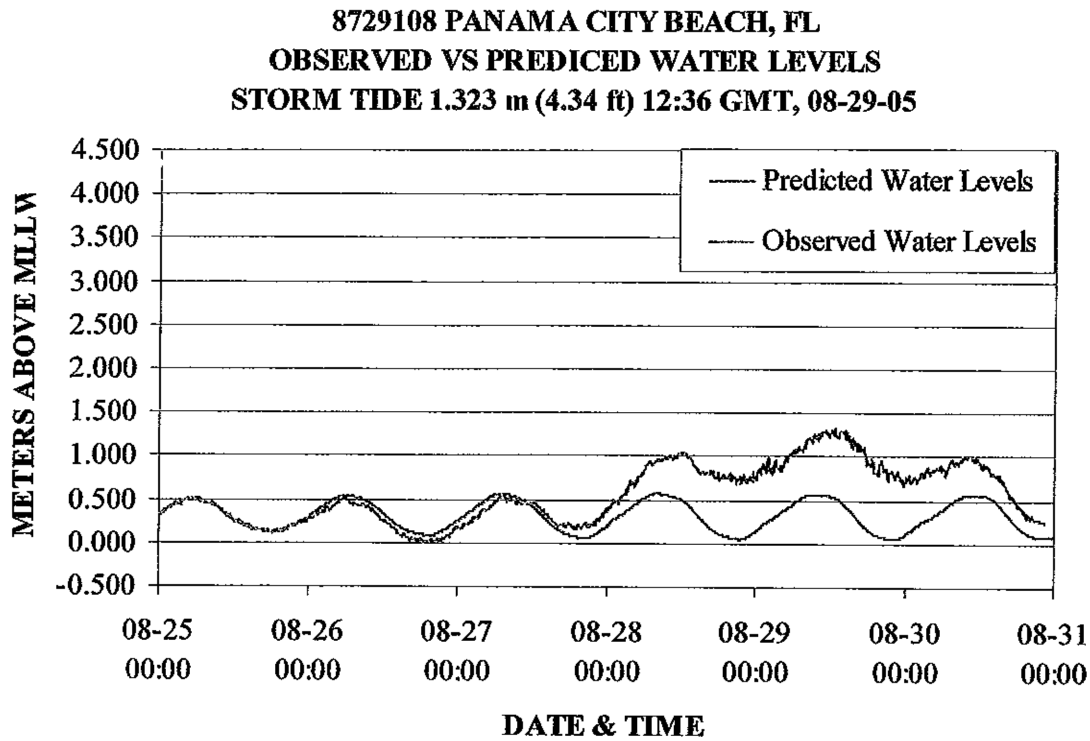


Figure 10: Time series of observed and predicted water levels at Panama City Beach, FL, before, during, and after Hurricane KATRINA.

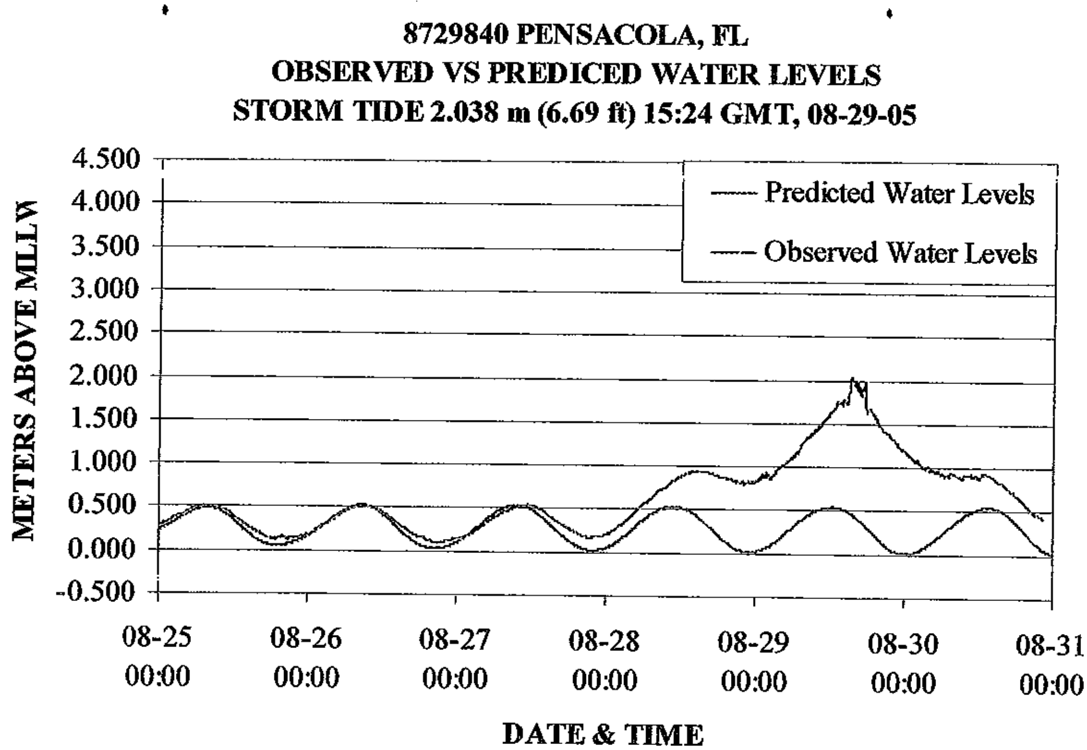


Figure 11: Time series of observed and predicted water levels at Pensacola, FL, before, during, and after Hurricane KATRINA.

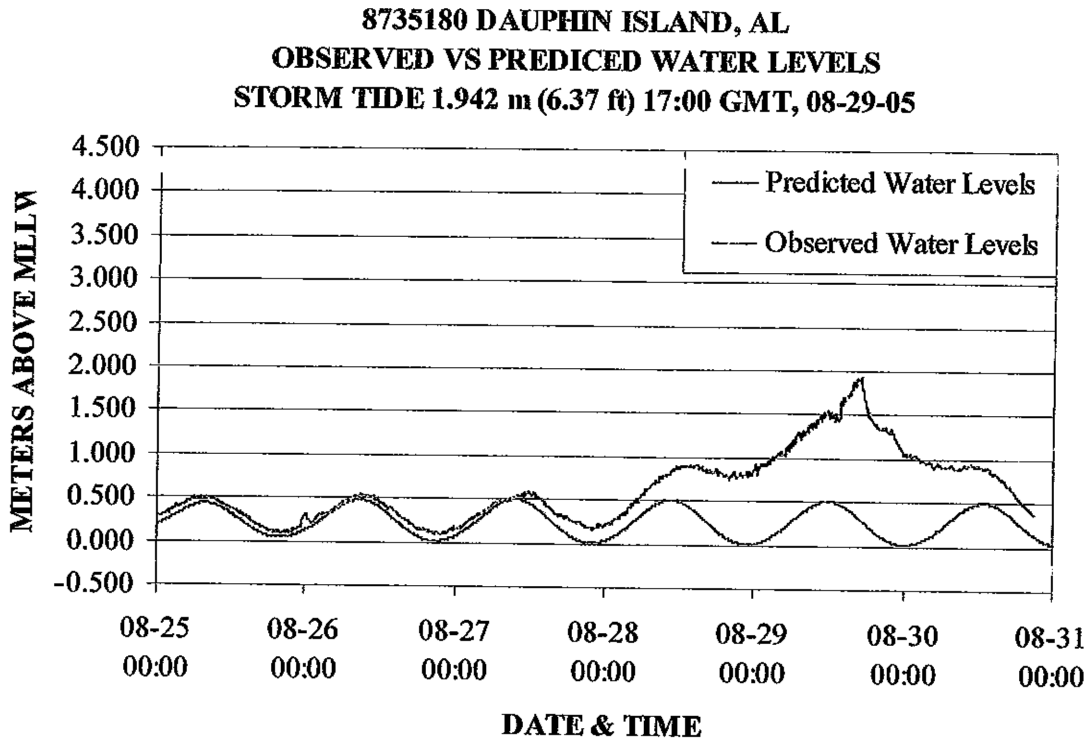


Figure 12: Time series of observed and predicted water levels at Dauphin Island, AL, before, during and after Hurricane KATRINA.

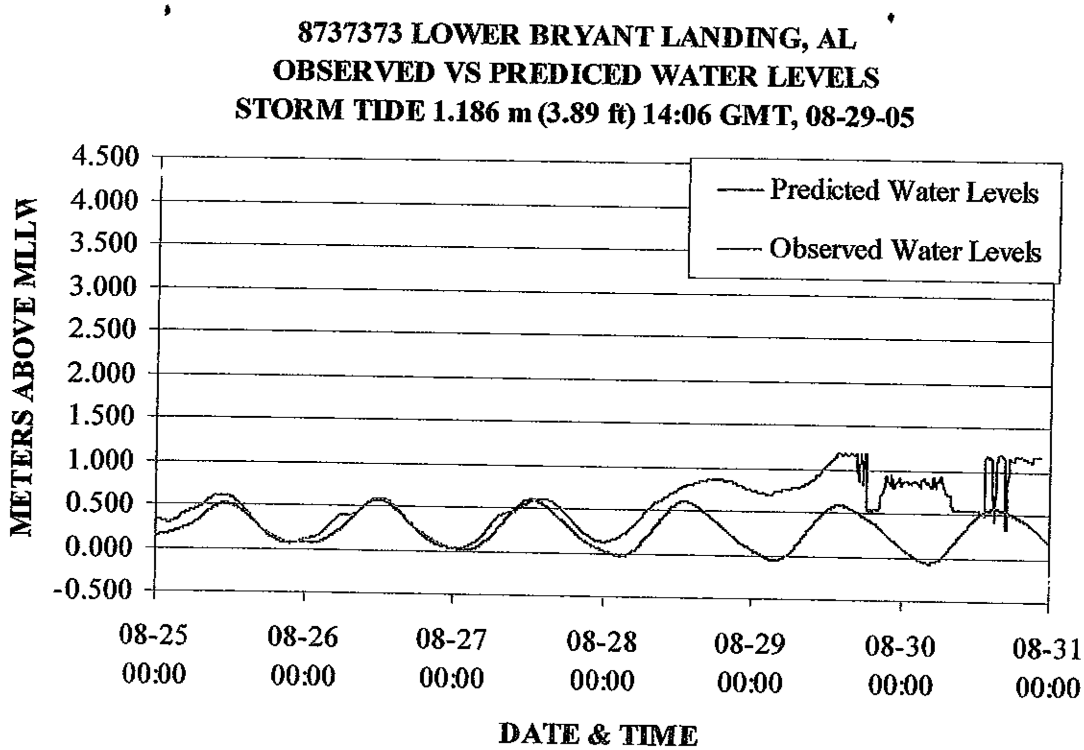


Figure 13: Time series of observed and predicted water levels at Lower Bryant Landing, AL, before, during, and after Hurricane KATRINA. Sensor malfunction noted at elevated water levels.

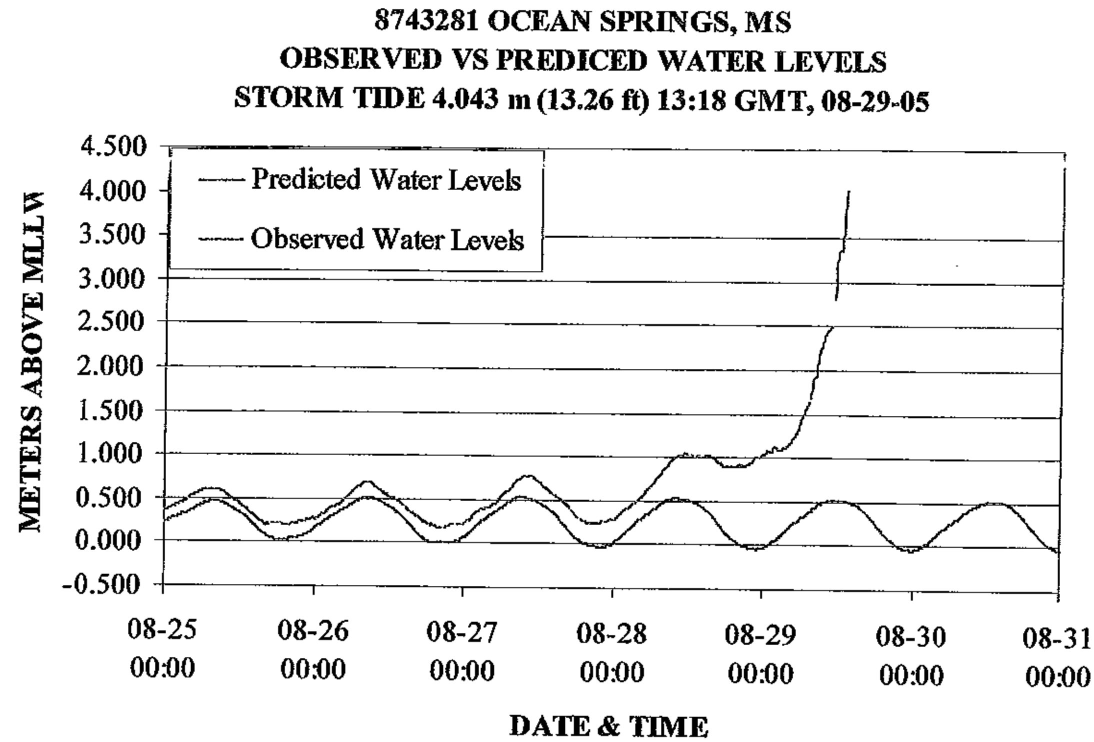


Figure 14: Time series of observed and predicted water levels at Ocean Spring, MS, before, during, and after Hurricane KATRINA. Station ceased transmissions and did not record a maximum elevation.

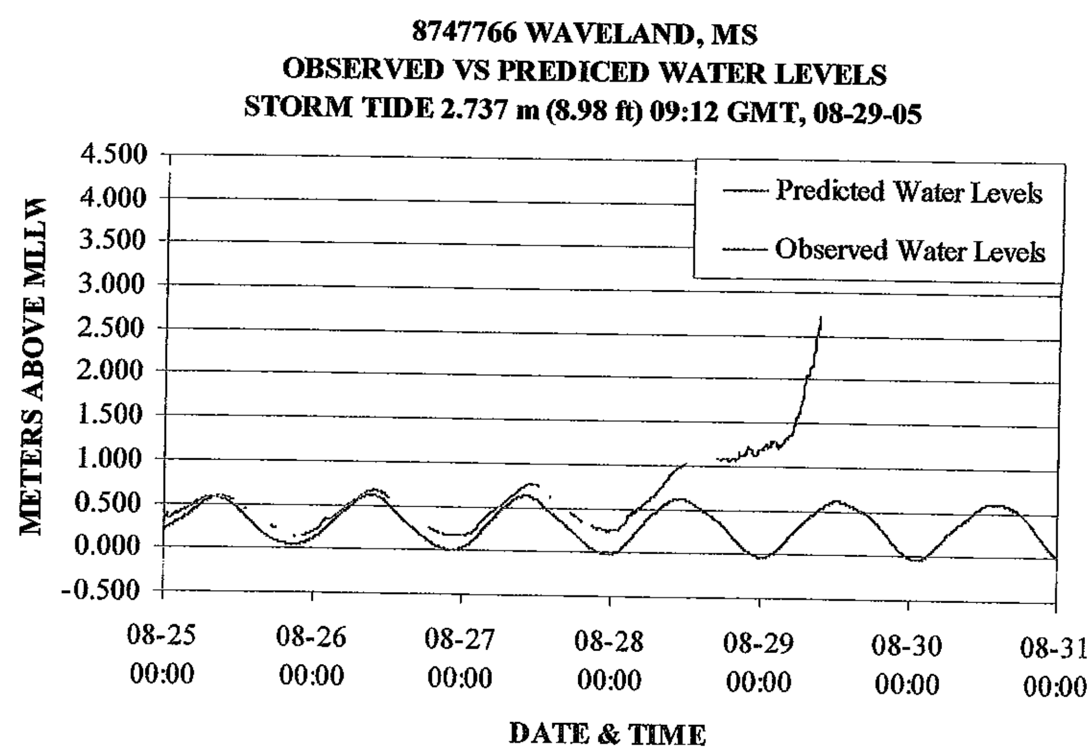


Figure 15: Time series of observed and predicted water levels at Waveland, MS, before, during, and after Hurricane KATRINA. Station ceased transmissions and did not record a maximum elevation.

8742221 HORN ISLAND, MS
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 2.856 m (9.37 ft) 04:48 GMT, 08-29-05

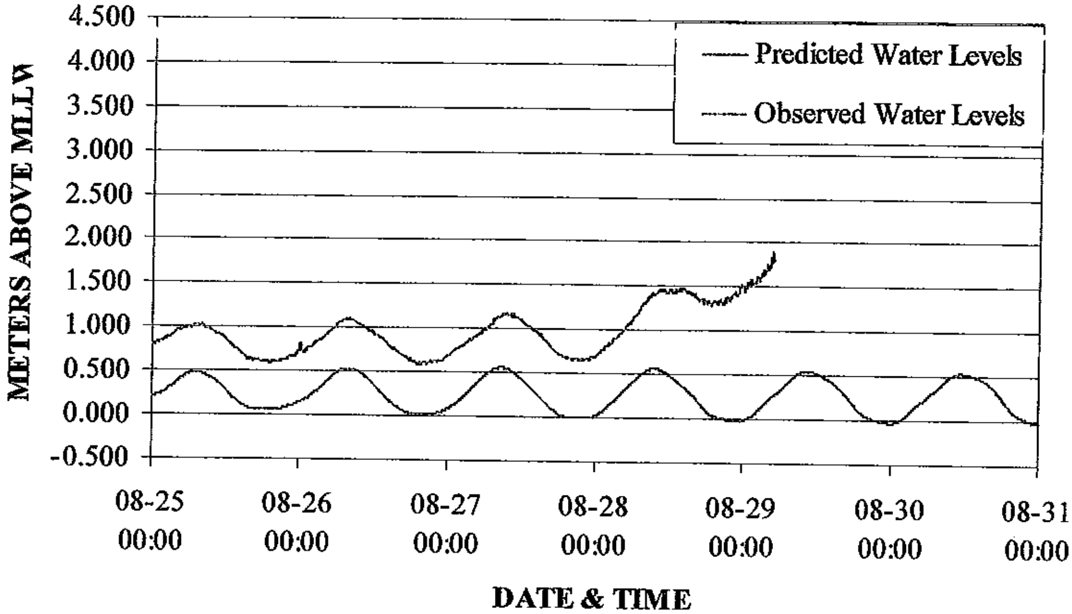


Figure 16: Time series of observed and predicted water levels at Horn Island, MS, before, during, and after Hurricane KATRINA. Station ceased transmissions and did not record a maximum elevation.

8744117 BILOXI, MS
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 1.316 m (4.318 ft) 07:42 GMT, 08-29-05

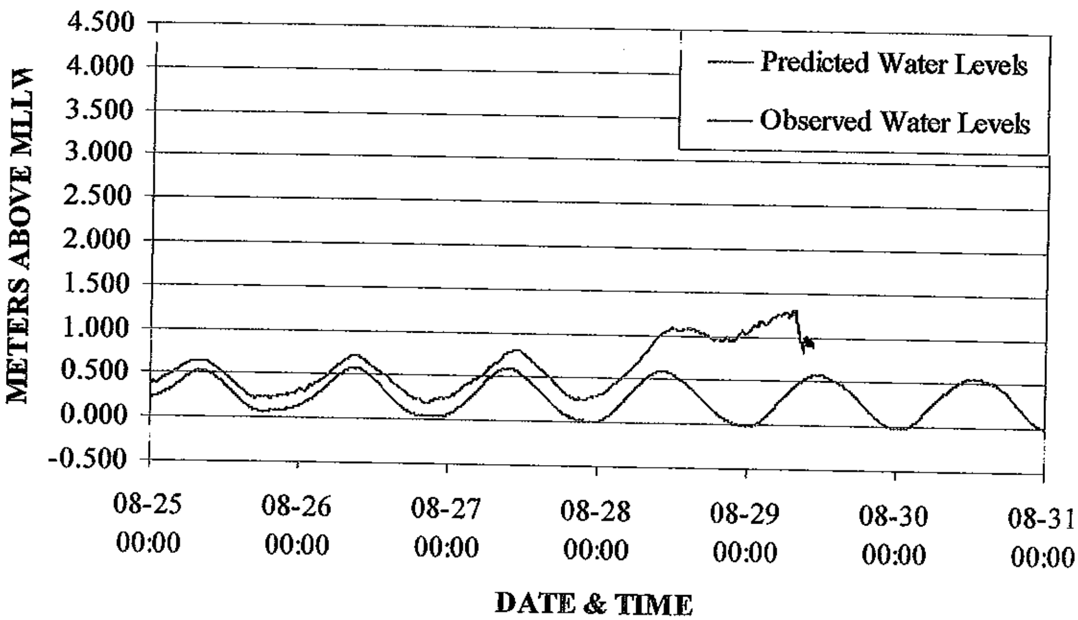


Figure 17: Time series of observed and predicted water levels at Ocean Spring, MS, before, during, and after Hurricane KATRINA. Station ceased transmissions and did not record a maximum elevation.

8762372 EAST BANK, LABRANCHE, LA
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 0.712 m (2.34 ft) 06:18 GMT, 08-29-05

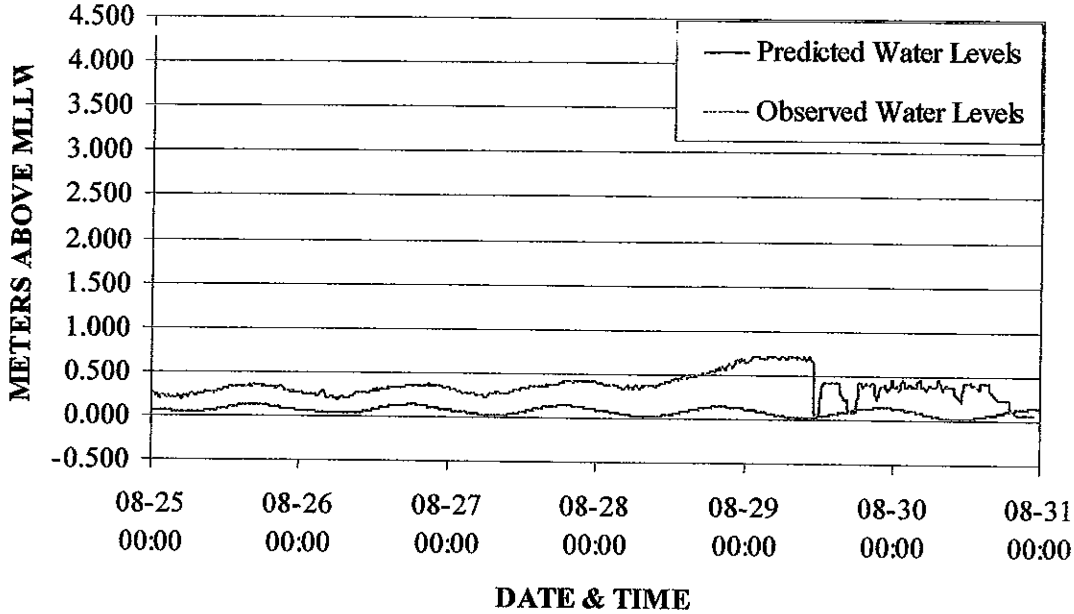


Figure 18: Time series of observed and predicted water levels at East Bank, LaBranche, LA, before, during, and after Hurricane KATRINA. Sensor malfunction noted at elevated water levels.

8762482 WEST BANK, BAYOU BAUCHE, LA
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 0.482 m (1.58 ft) 15:36 GMT, 08-29-05

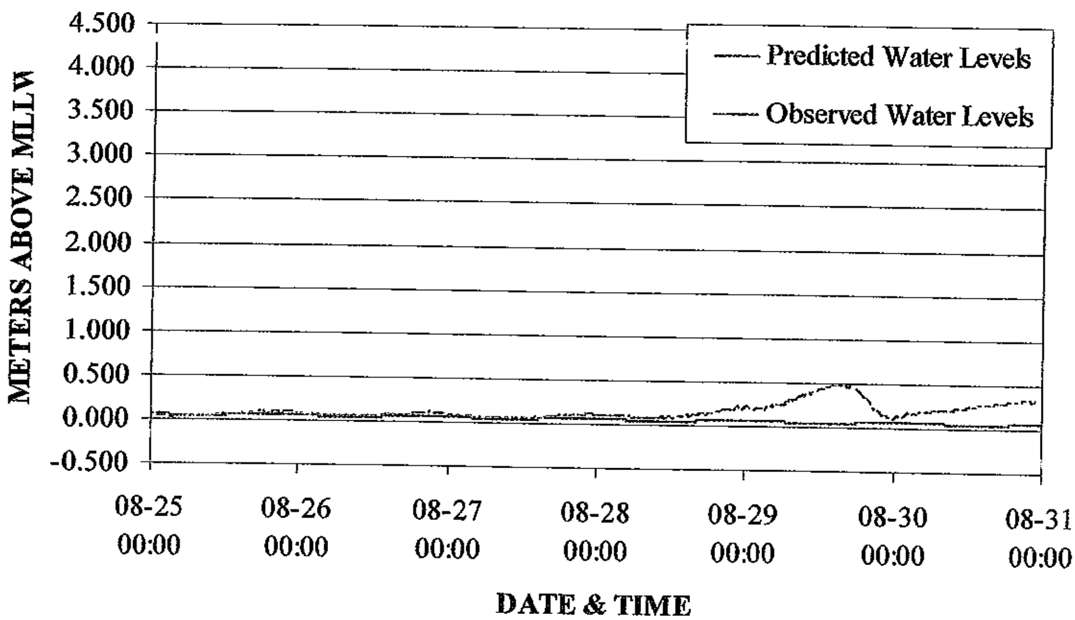


Figure 19: Time series of observed and predicted water levels at West Bank, Bayou Bauche, LA, before, during, and after Hurricane KATRINA.

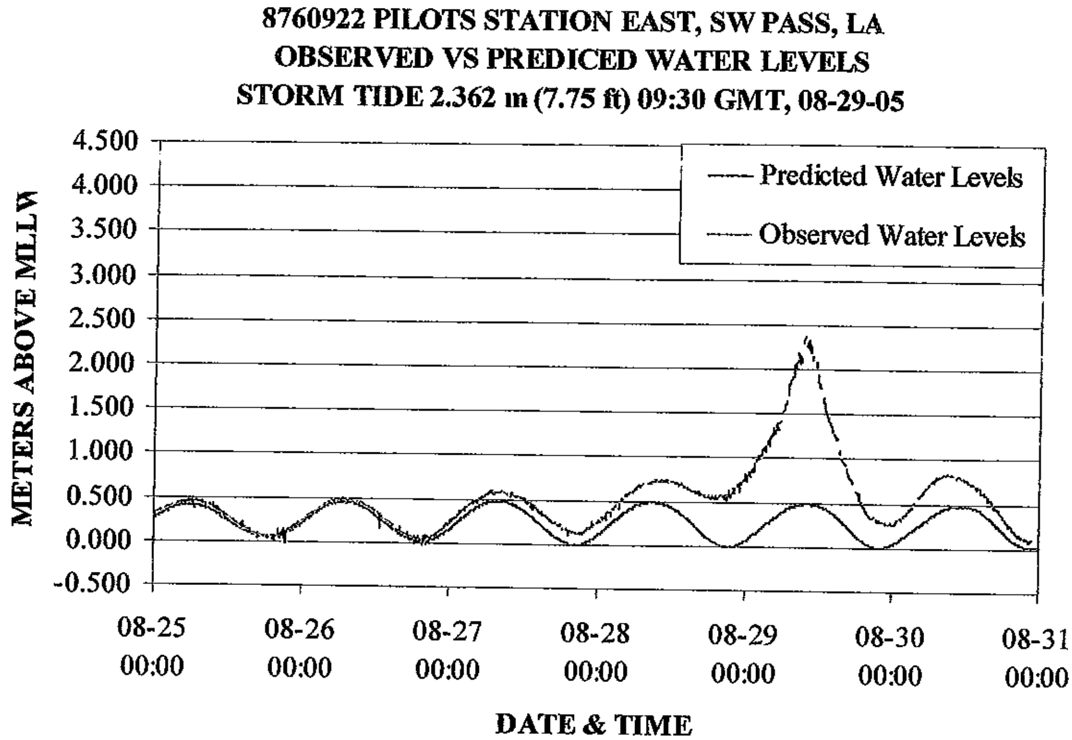


Figure 20: Time series of observed and predicted water levels at Pilots Station East, SW Pass, LA, before, during, and after Hurricane KATRINA.

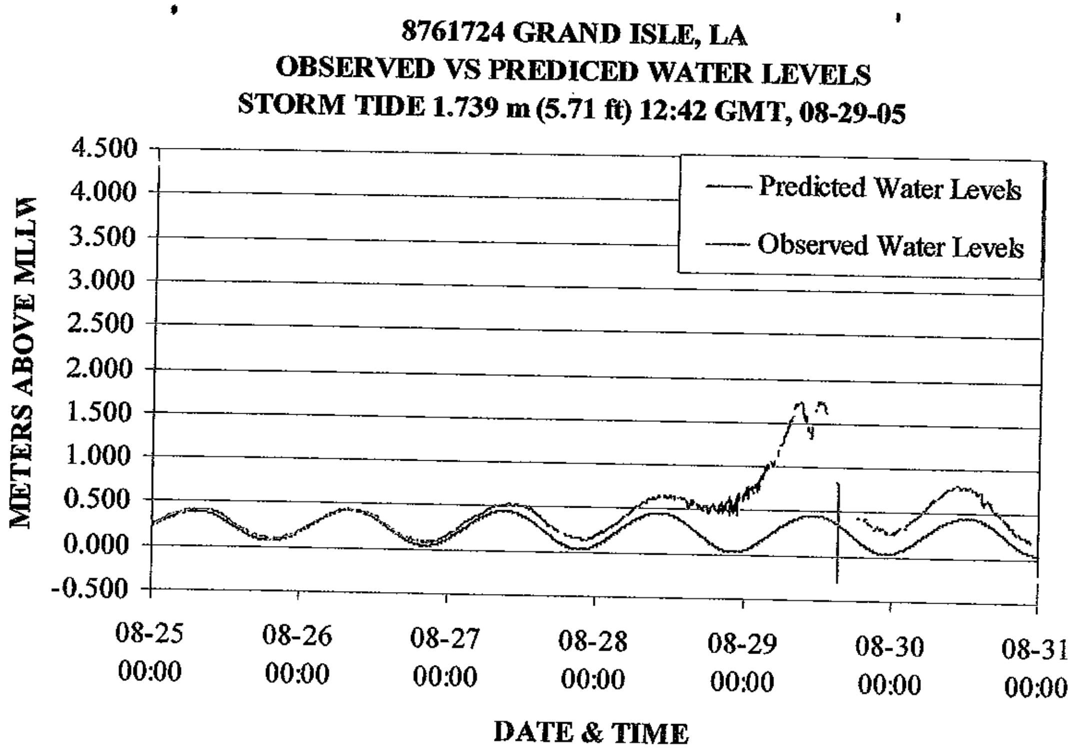


Figure 21: Time series of observed and predicted water levels at Grand Isle, LA, before, during, and after Hurricane KATRINA. Sensor malfunction noted at elevated water levels.

8764044 TESORO MARINE TERMINAL, LA
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 0.305 m (1.00 ft) 11:12 GMT, 08-30-05

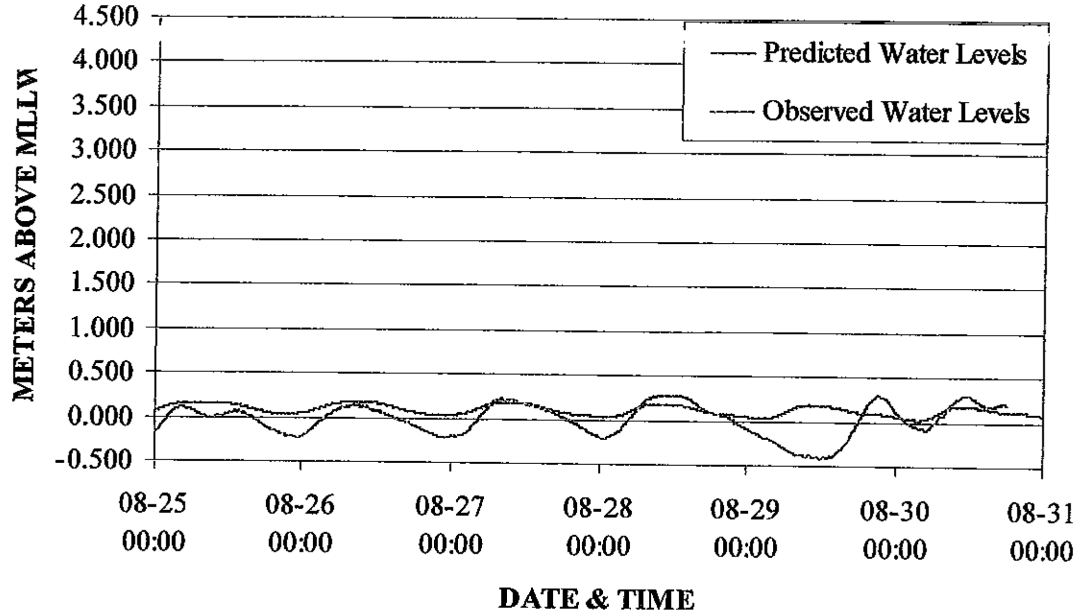


Figure 22: Time series of observed and predicted water levels at Tesoro Marine Terminal, LA, before, during, and after Hurricane KATRINA.

8768094 CALCASIEU PASS, LA
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 0.938 m (3.08 ft) 07:18 GMT, 08-29-05

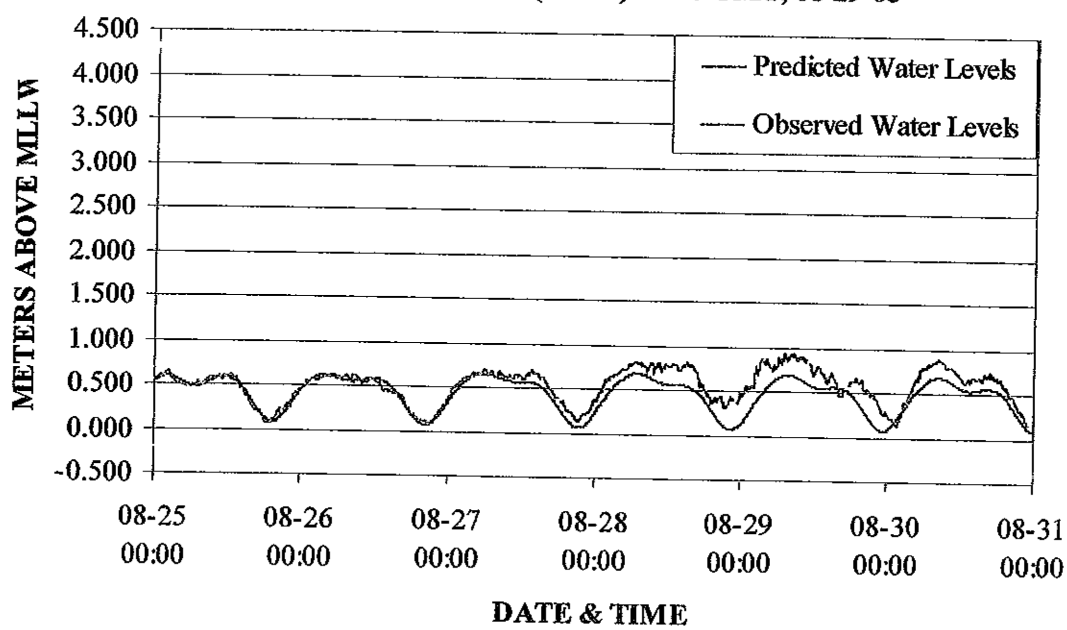


Figure 23: Time series of observed and predicted water levels at Calcasieu Pass, LA, before, during, and after Hurricane KATRINA.

8770570 SABINE PASS NORTH, TX
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 0.759 m (2.49 ft) 08:06 GMT, 08-29-05

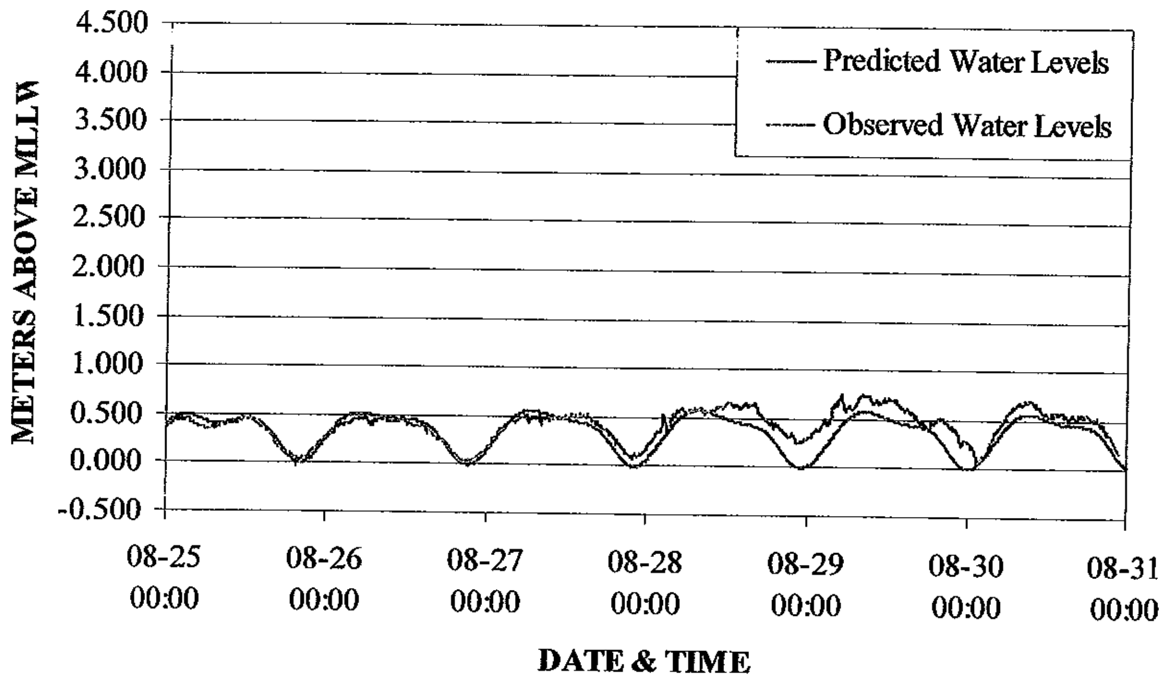


Figure 24: Time series of observed and predicted water levels at Sabine Pass, North, TX, before, during, and after Hurricane KATRINA.

8771341 GALVESTON BAY ENTRANCE, NORTH JETTY, TX
OBSERVED VS PREDICED WATER LEVELS
STORM TIDE 0.892 m (2.93 ft) 06:42 GMT, 08-29-05

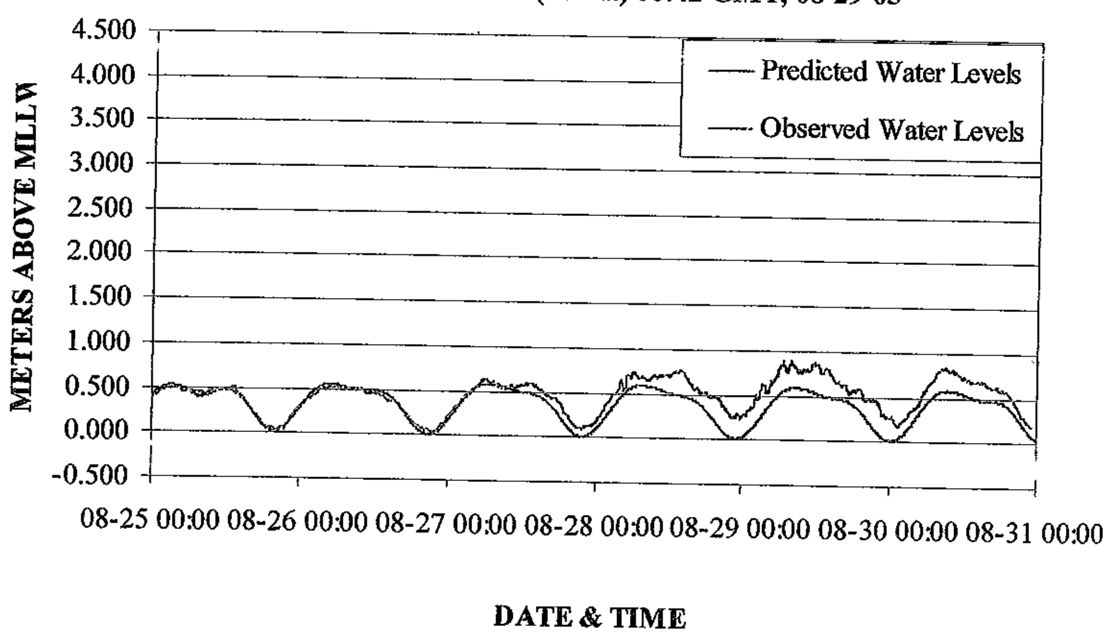


Figure 25: Time series of observed and predicted water levels at Galveston Bay Entrance, TX, before, during, and after Hurricane KATRINA.

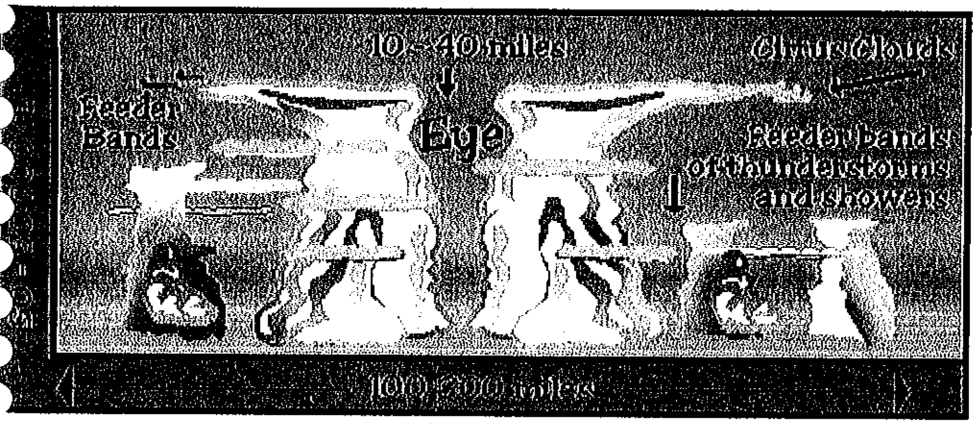
APPENDIX

Station Name	Station ID	Latitude	Longitude
Trident Pier, FL	8721604	28° 24.9' N	80° 35.6' W
Virginia Key, FL	8723214	25° 43.9' N	80° 09.7' W
Vaca Key, FL	8723970	24° 42.7' N	81° 06.3' W
Key West, FL	8724580	24° 33.2' N	81° 48.5' W
Clearwater Beach, FL	8726724	27° 58.6' N	82° 49.9' W
Cedar Key, FL	8727520	29° 08.1' N	83° 01.9' W
Apalachicola, FL	8728690	29° 43.6' N	84° 58.9' W
Panama City, FL	8729108	30° 09.1' N	85° 40.0' W
Panama City Beach, FL	8729210	30° 12.8' N	85° 52.8' W
Pensacola, FL	8729840	30° 24.2' N	87° 12.7' W
Lower Bryant Landing, AL	8737373	30° 58.7' N	87° 52.4' W
Dauphin Island , AL	8735180	30° 15.0' N	88° 04.5' W
Horn Island, MS	8742221	30° 14.3' N	88° 40.0' W
Ocean Springs, MS	8743281	30° 23.5' N	88° 47.9' W
Biloxi, MS	8744117	30° 24.7' N	88° 54.2' W
Waveland, MS	8747766	30° 16.9' N	88° 22.0' W
East Bank, LaBranche, LA	8762372	30° 03.0' N	90° 21.1' W
West Bank, Bayou Gauche, LA	8762482	29° 46.6' N	90° 25.1' W
Pilots Station, SW Pass, LA	8760922	30° 55.9' N	88° 24.4' W
Grand Isle, LA	8761724	30° 15.8' N	88° 57.4 W
Tesoro Marine Terminal, LA	8764044	29° 40.0' N	91° 14.2' W
Calcasieu, LA	8768094	29° 45.9' N	93° 20.6' W
Sabine, TX	8770570	29° 43.8' N	93° 52.2' W
Galveston Bay Entrance, TX	8771341	29° 21.5' N	94° 43.5' W

APPENDIX E

HURRICANES

'he most destructive and extensive of all weather phenomenon is the hurricane. Winds in a tornado can nomentarily exceed those of a hurricane, but the life cycle of a tornado is primarily measured in minutes. The life cycle of a hurricane, however, is measured in weeks and its extraordinary size exceeds any other meteorological phenomenon. About six hurricanes develop each year in the North Atlantic during the hurricane season (June 1 to lovember 30).



Each part of the world has its own name for the fully mature tropical cyclone. They are hurricanes in the North Atlantic, Caribbean, and Eastern Pacific Ocean. In the Western Pacific they are known as typhoons, and simply as cyclones in the Indian Ocean.

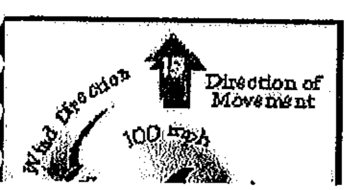
A hurricane originates as a tropical cyclone over low latitude ocean areas. Several phases of development take place before a tropical cyclone develops into a hurricane. Growth is determined by the strength of the sustained wind: the opical depression has winds less than 36 mph; winds of a tropical storm range from 36 and 74 mph. The hurricane as sustained winds greater than 74 mph.

North Atlantic tropical cyclones usually move iitially in a westward direction with the prevailing easterly trade winds. They gradually drift northward as they move into higher latitudes with speeds from 10 to 15 mph. As ie storms recurve toward a more northerly irection, the speed of movement increases ignificantly as the system comes under the ifluence of the westerly winds aloft.

TROPICAL CYCLONES

DEPRESSION	36 mph
TROPICAL STORM	36 to 74 mph
HURRICANE	more than 74 mph

'he near cloudless center of a tropical cyclone, called the *eye*, is peculiarly unique. It normally develops during the ropical storm stage and is usually well pronounced in the hurricane stage. It is characterized by the lowest pressure, onfused sea conditions, light and variable winds, and temperatures higher than outside the eye. They are not ecessarily circular. Some eyes are elongated in shape, usually in the direction of movement. The average diameter fifteen miles, but can range from two to forty miles although eyes of 70 to 90 miles in diameter have been eported. The eye is surrounded by cumulonimbus wall clouds that extend to altitudes of 50,000 to 60,000 feet.

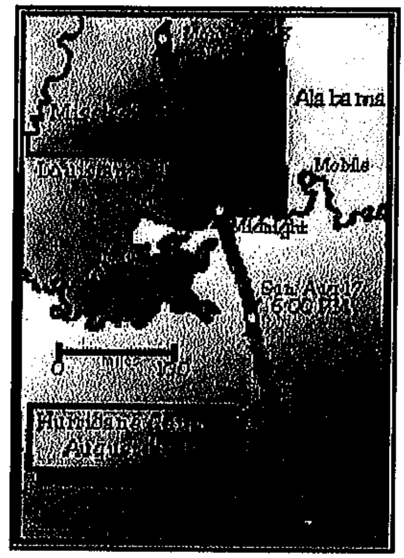


Winds in a hurricane are not uniform, varying from quadrant to quadrant. For example, a hurricane with 100 mph winds, moving north at 15 mph, will have 115 mph winds in the right front sector, but only 85 mph winds in the left front. This is due

to the forward speed either adding to, or taking from the total wind force.

The greatest hurricane damage occurs just to the right of the storm track. The combination of sustained strong winds reinforced by the movement of the storm, high tides, run off from torrential rains, and reduced atmospheric pressure can result in a "storm surge." The ensuing wall of water can reduce coastal areas to shambles.

On August 18, 1969, Hurricane Camille made landfall on the coast of Mississippi. The storm was one of the most intense ever to strike the Gulf Coast. Camille was accompanied by winds gusting to 190 mph and a storm surge estimated to be 20 to 26 feet. The toll in Mississippi and Louisiana was 135 people killed and 42 missing. By the time the remains of Camille dissipated in southwestern Virginia, over 300 people were dead and approximately $1.4 billion in damage was inflicted.



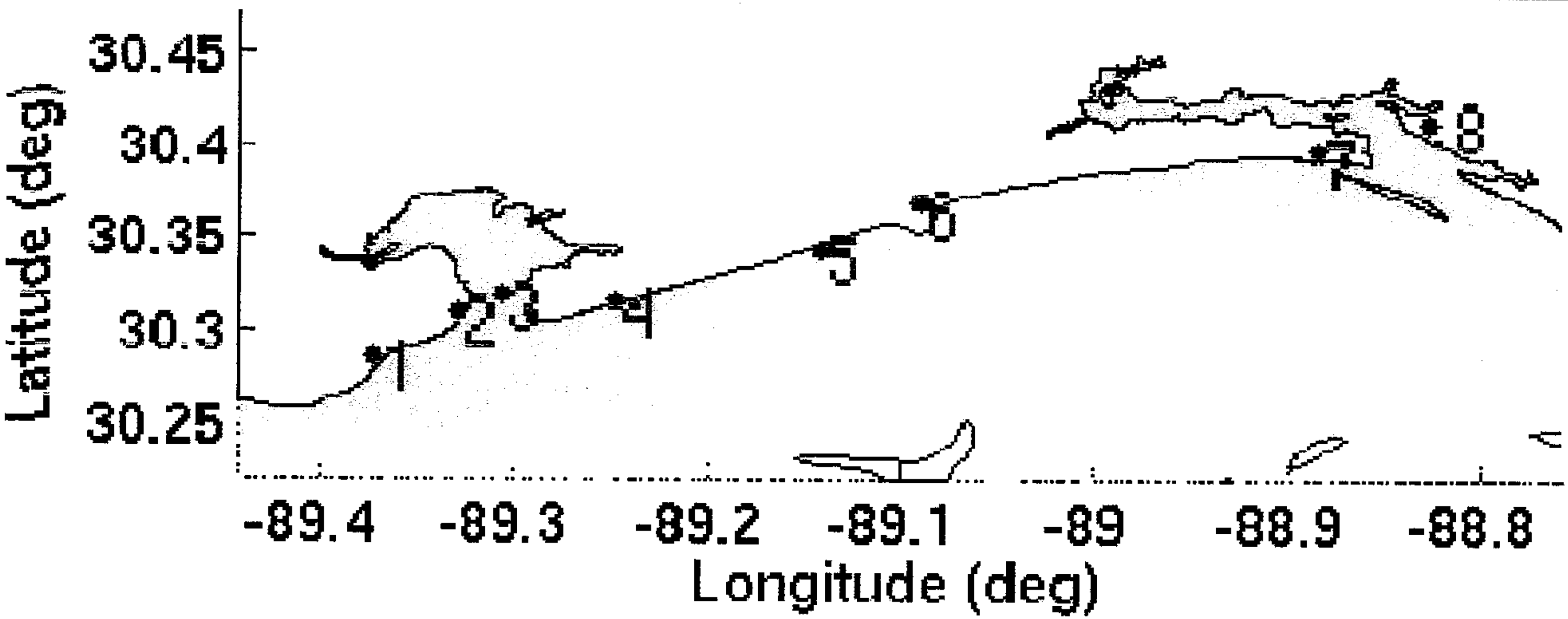
Back to Top

Preliminary Model Hindcast of Hurricane Katrina Storm Surge

21 November, 2005

CNMOC
Stennis Space Center, MS

Selected Landmarks



1. Waveland City Hall
2. Bay St. Louis City Hall
3. Bay St. Louis bridge
4. Pass Christian City Hall
5. Long Beach harbor
6. Gulfport City Hall
7. Biloxi City Hall
8. Ocean Springs City Hall

Preliminary Storm Surge Hindcasts

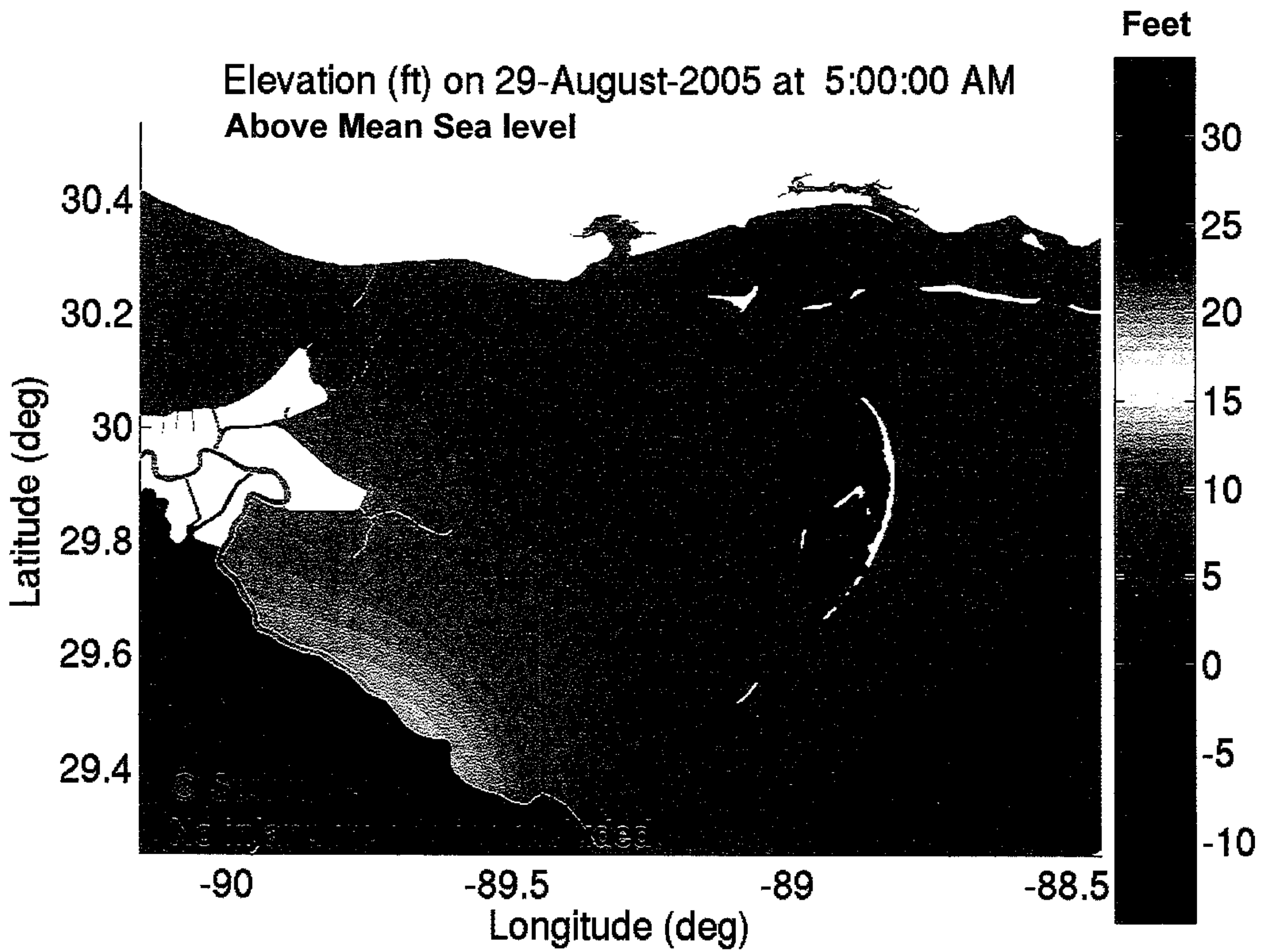
- Storm surge hindcasts are performed using the Advanced Circulation Model[1] (ADCIRC-2DDI).
- Inundation is not included in these simulations so inland flooding is not presented.
- Hurricane wind fields used to drive ADCIRC are obtained from the NOAA Hurricane Research Division of AOML

  http://www.aoml.noaa.gov/hrd/Storm_pages/katrina2005/wind.html
- These are PRELIMINARY results. When more detailed hurricane wind fields become available, updated storm surge hindcasts will be posted.

[1]Luettich, R.A., J.J. Westerrink, and N.W. Scheffner, 1992: ADCIRC: an advanced three-dimensional circulation model for shelves coasts and estuaries, report 1: theory and methodology of ADCIRC-2DDI and ADCIRC-3DL, Dredging Research Program Technical Report DRP-92-6, U.S. Army Engineers Waterways Experiment Station, Vicksburg, MS, 137p.

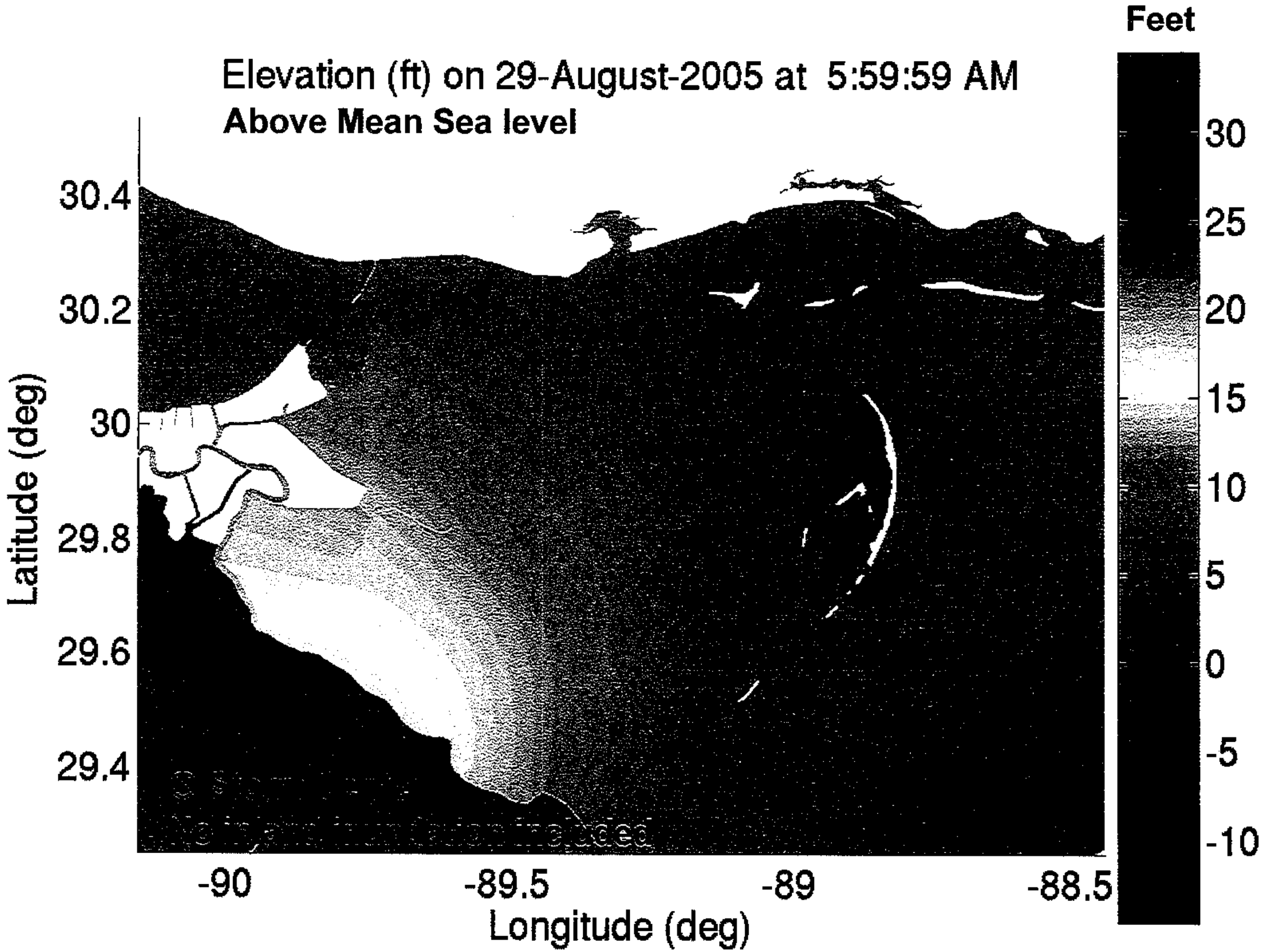
[2]Holland, G.J, 1980: An analytical model of the wind and pressure profiles in hurricanes, *Monthly Weather Review*, 106, 1212-1218.

ADCIRC Computed Tides + Surge

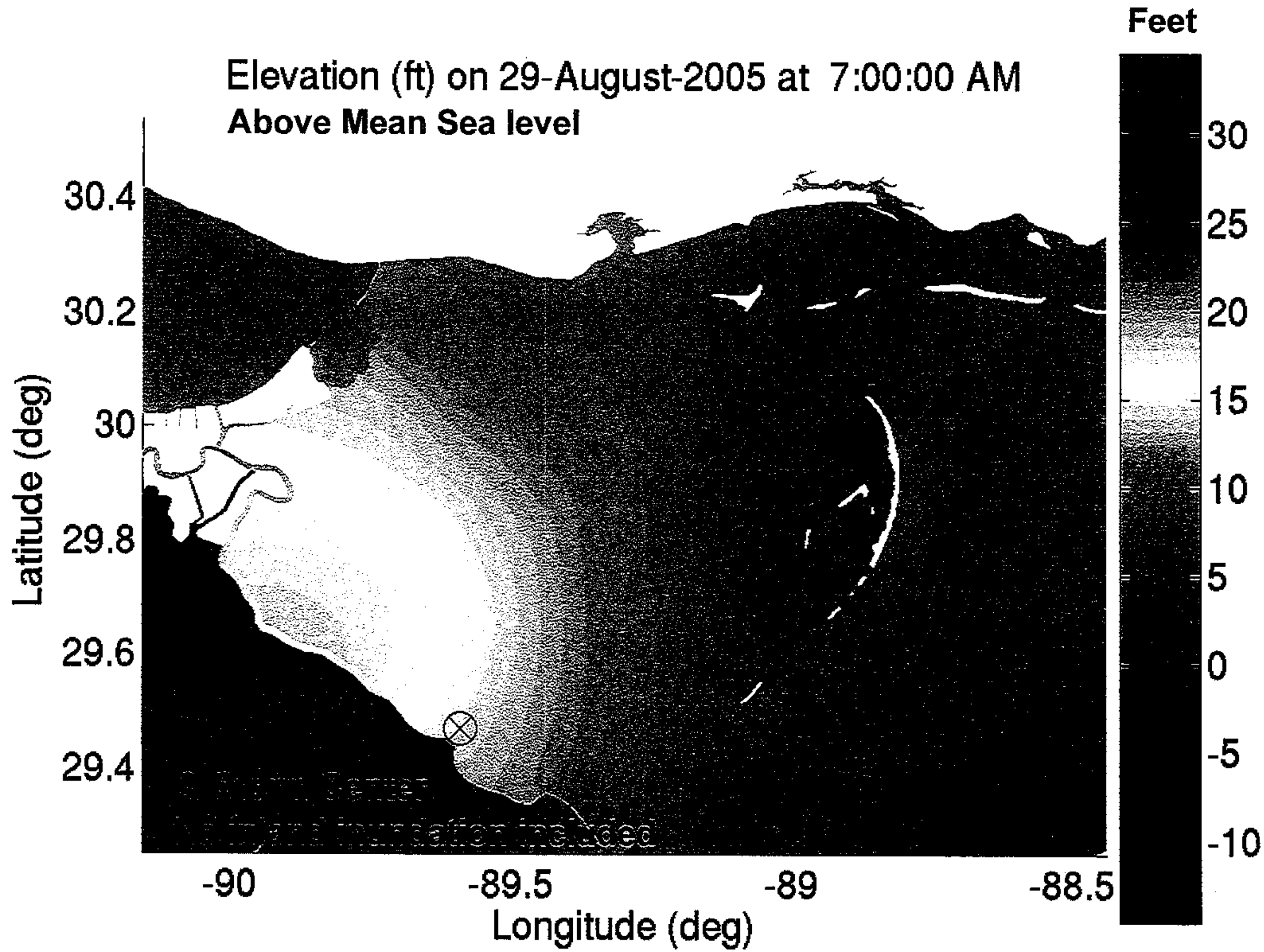


Preliminary Katrina Storm Surge Hindcasts

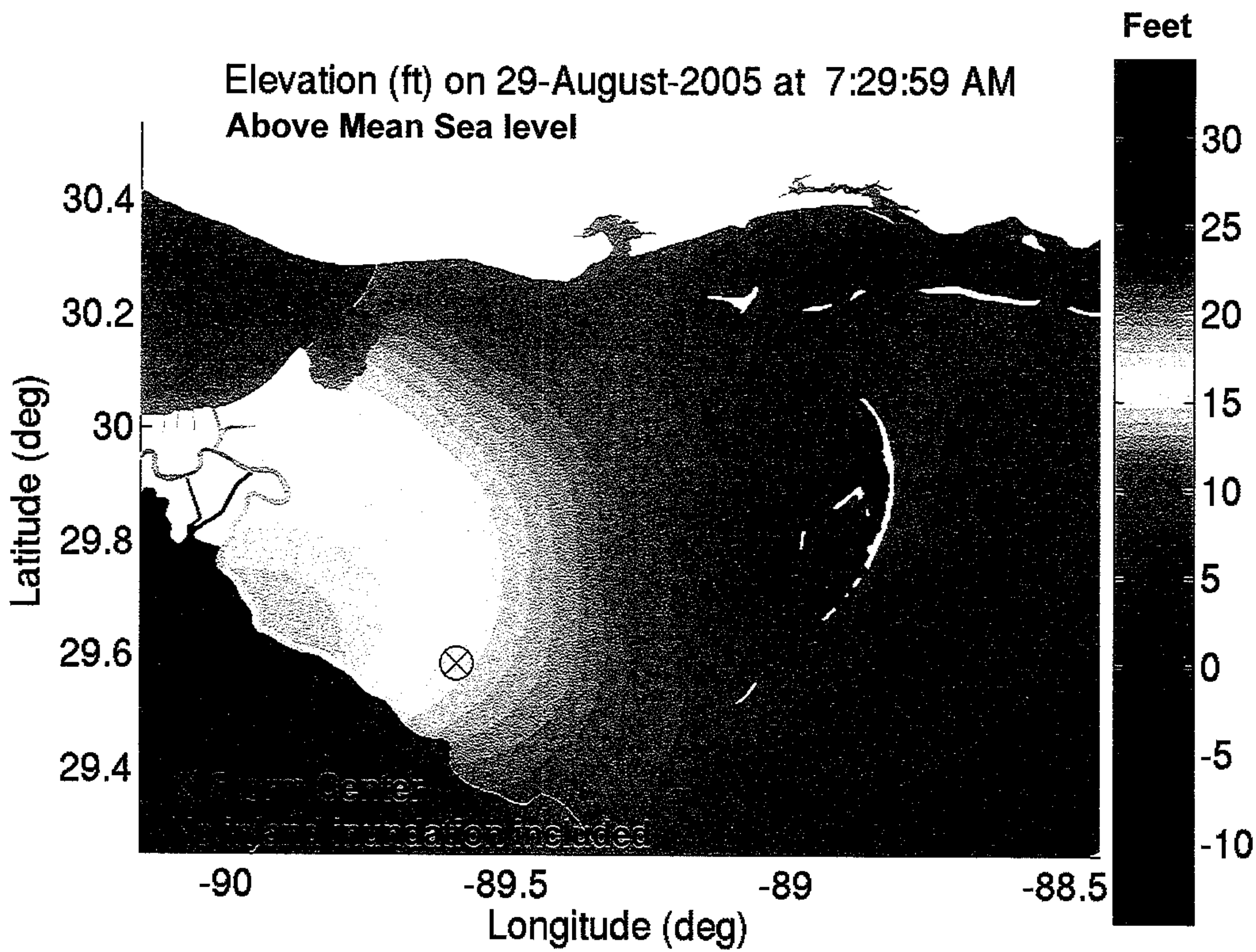
ADCIRC Computed Tides + Surge



ADCIRC Computed Tides + Surge



ADCIRC Computed Tides + Surge



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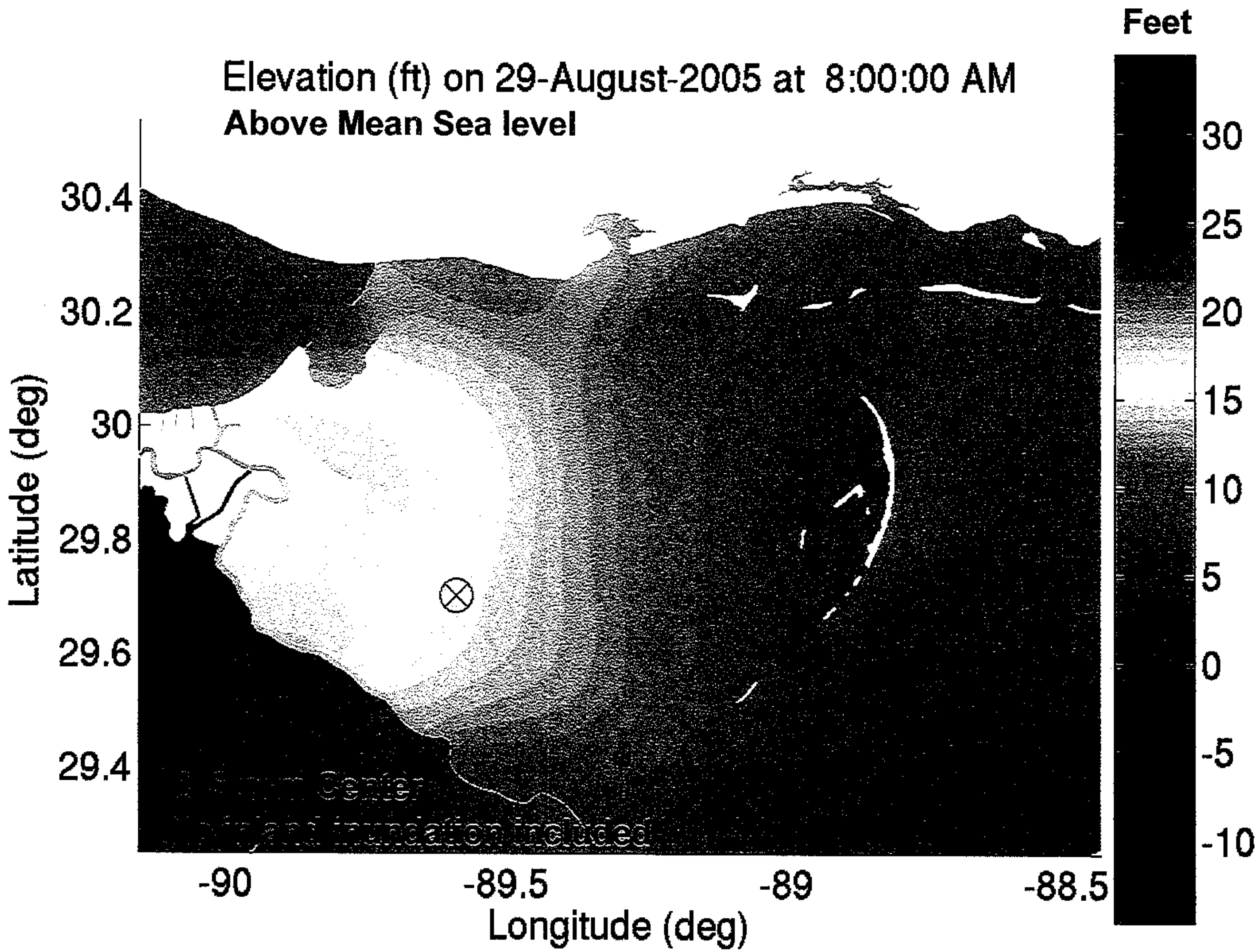
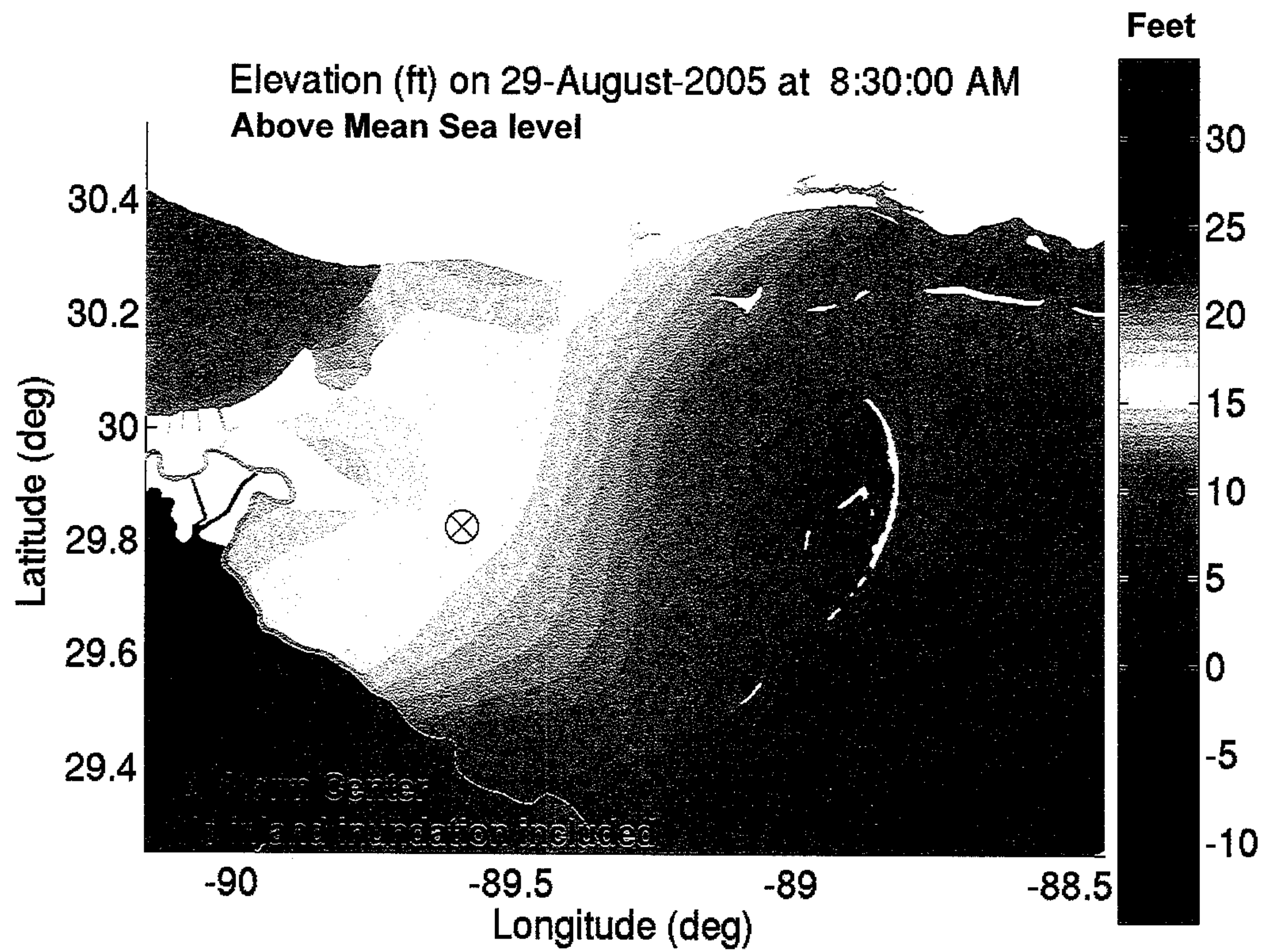


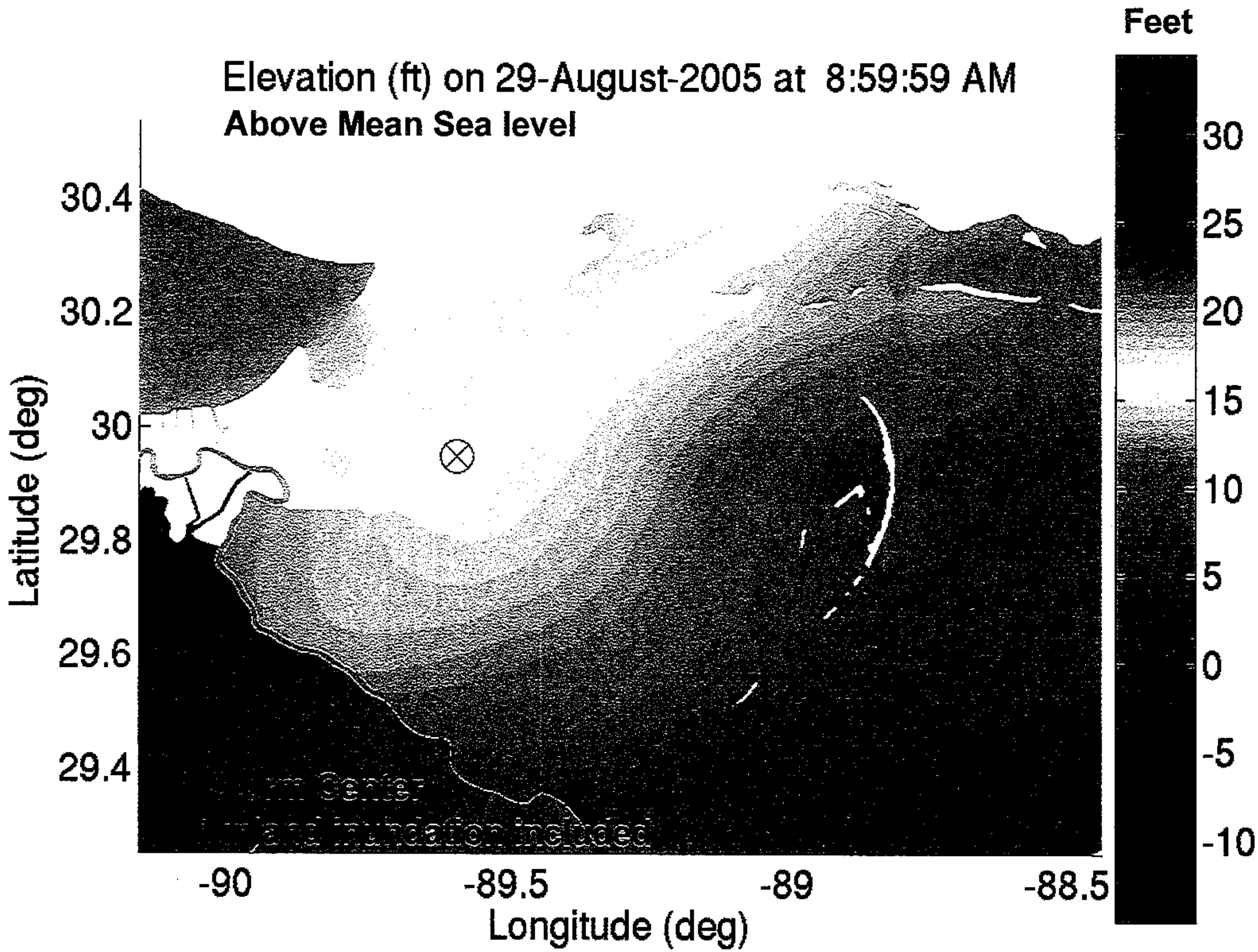
Preliminary Katrina Storm Surge Hindcasts

ADCIRC Computed Tides + Surge

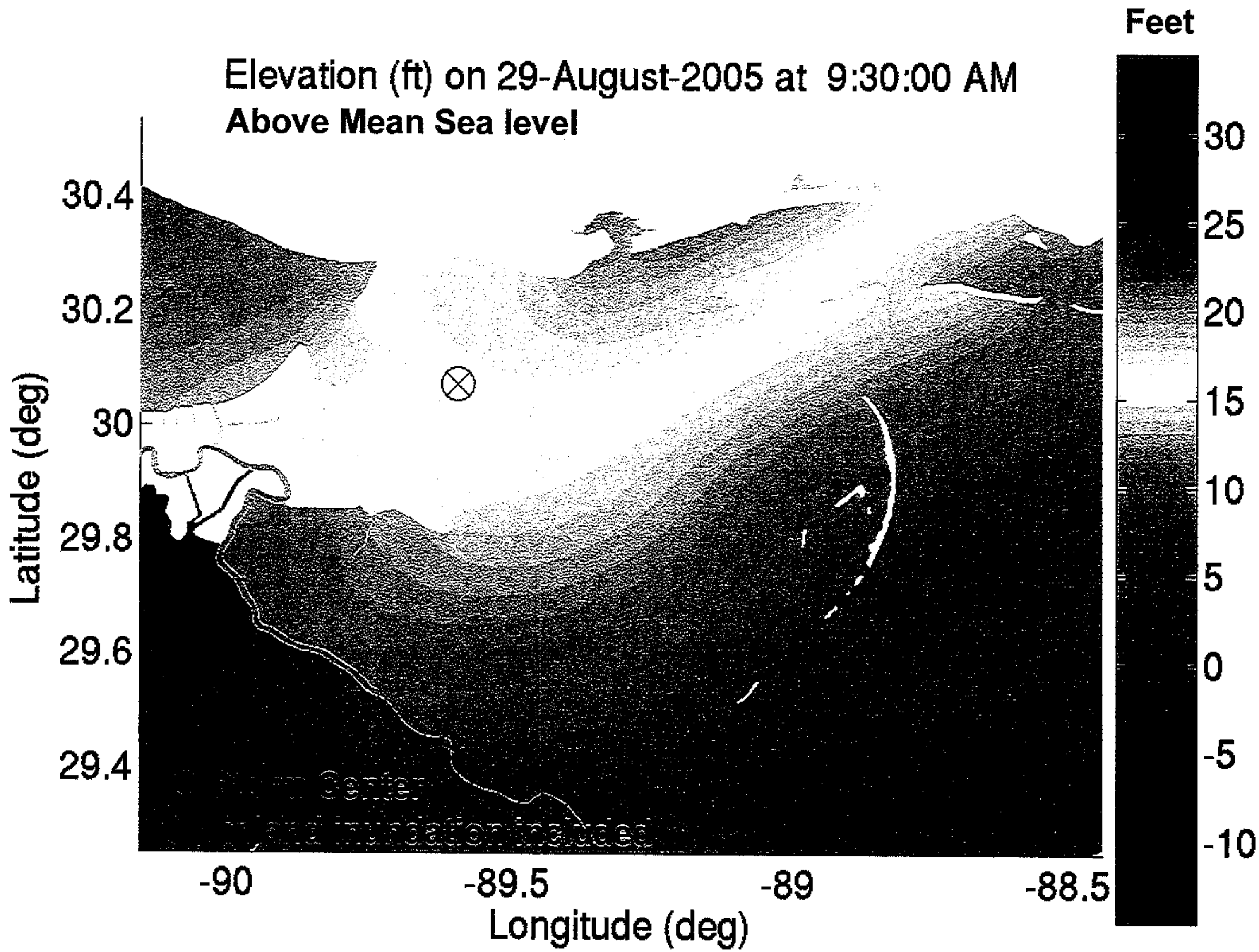


Preliminary Katrina Storm Surge Hindcasts

ADCIRC Computed Tides + Surge



ADCIRC Computed Tides + Surge



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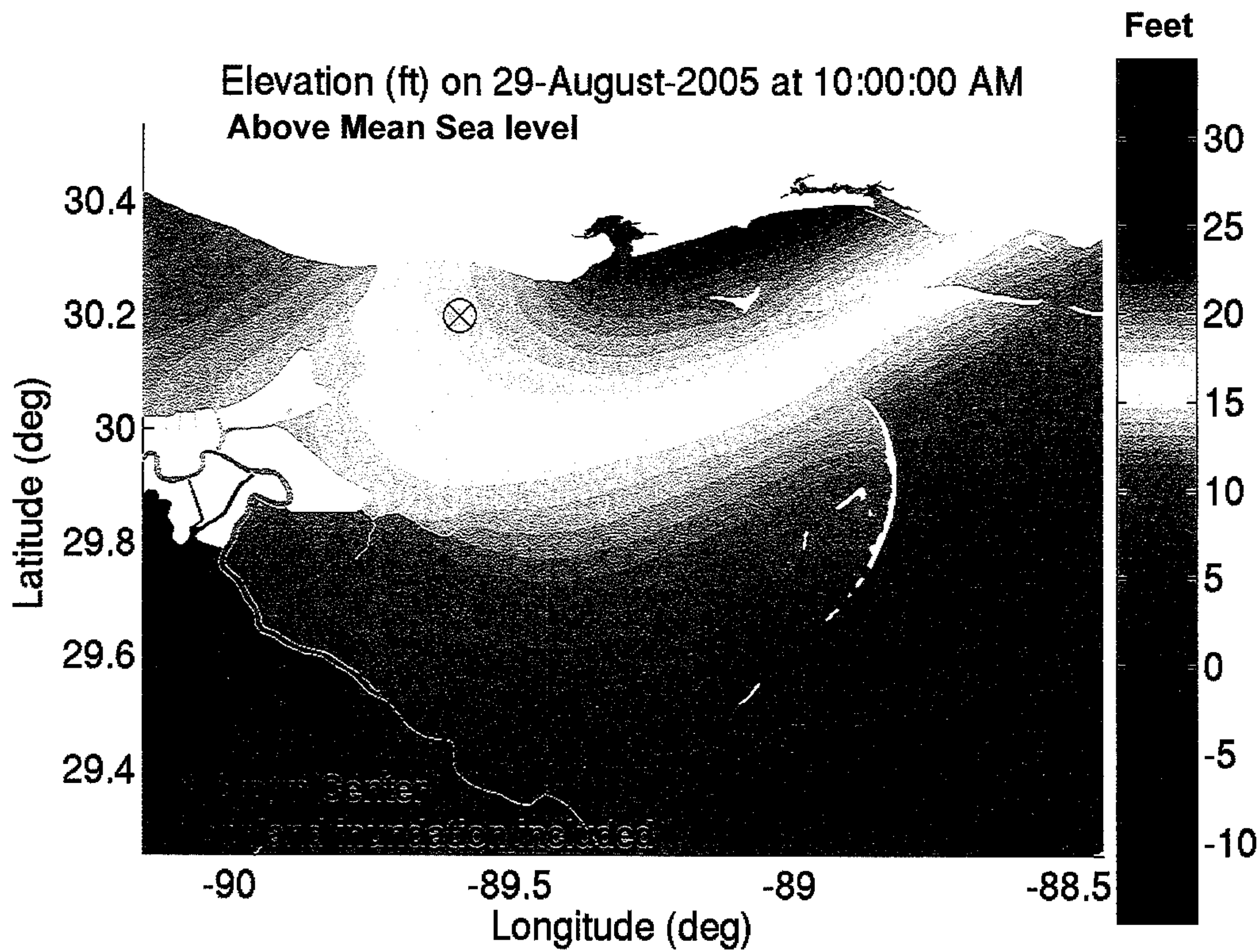
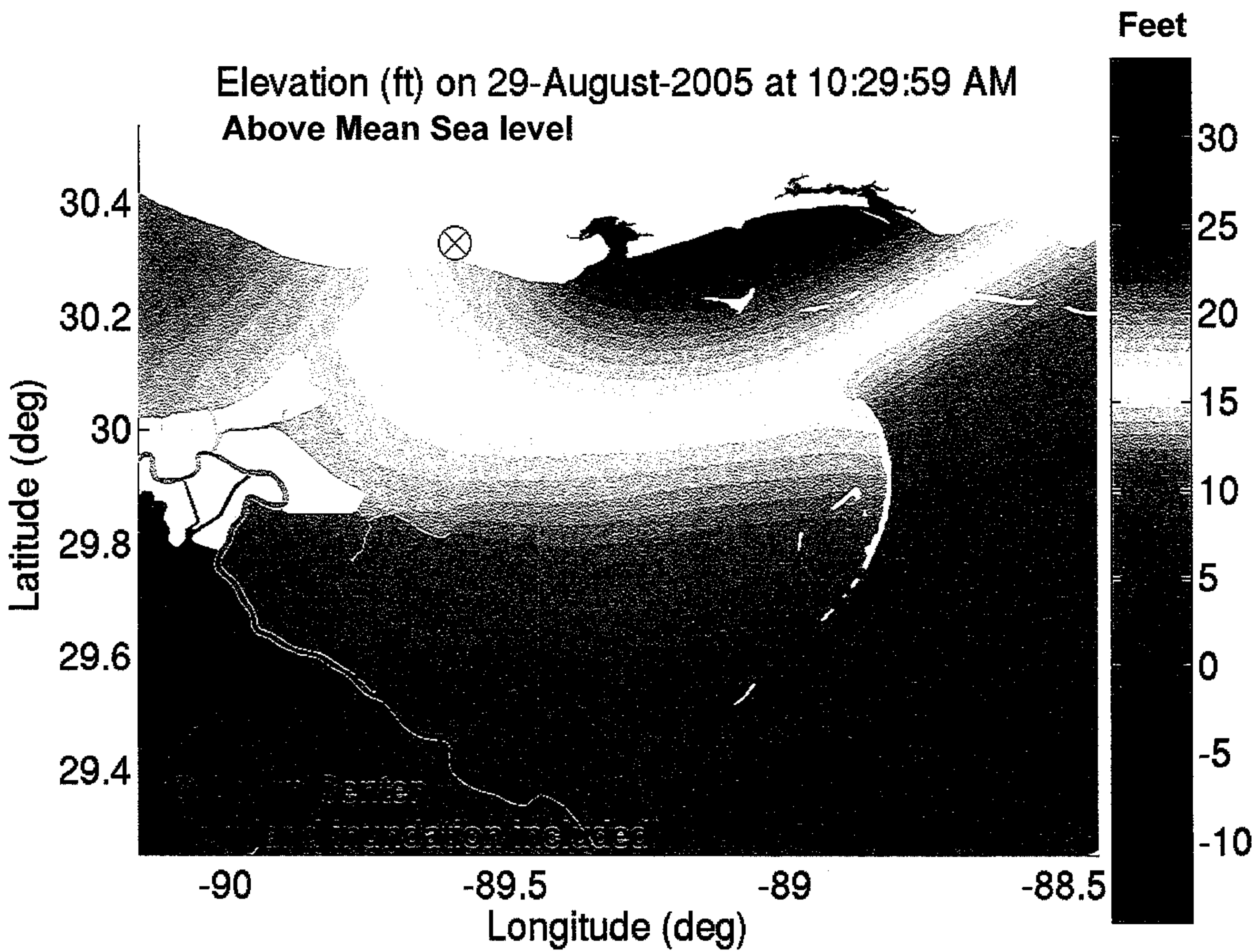


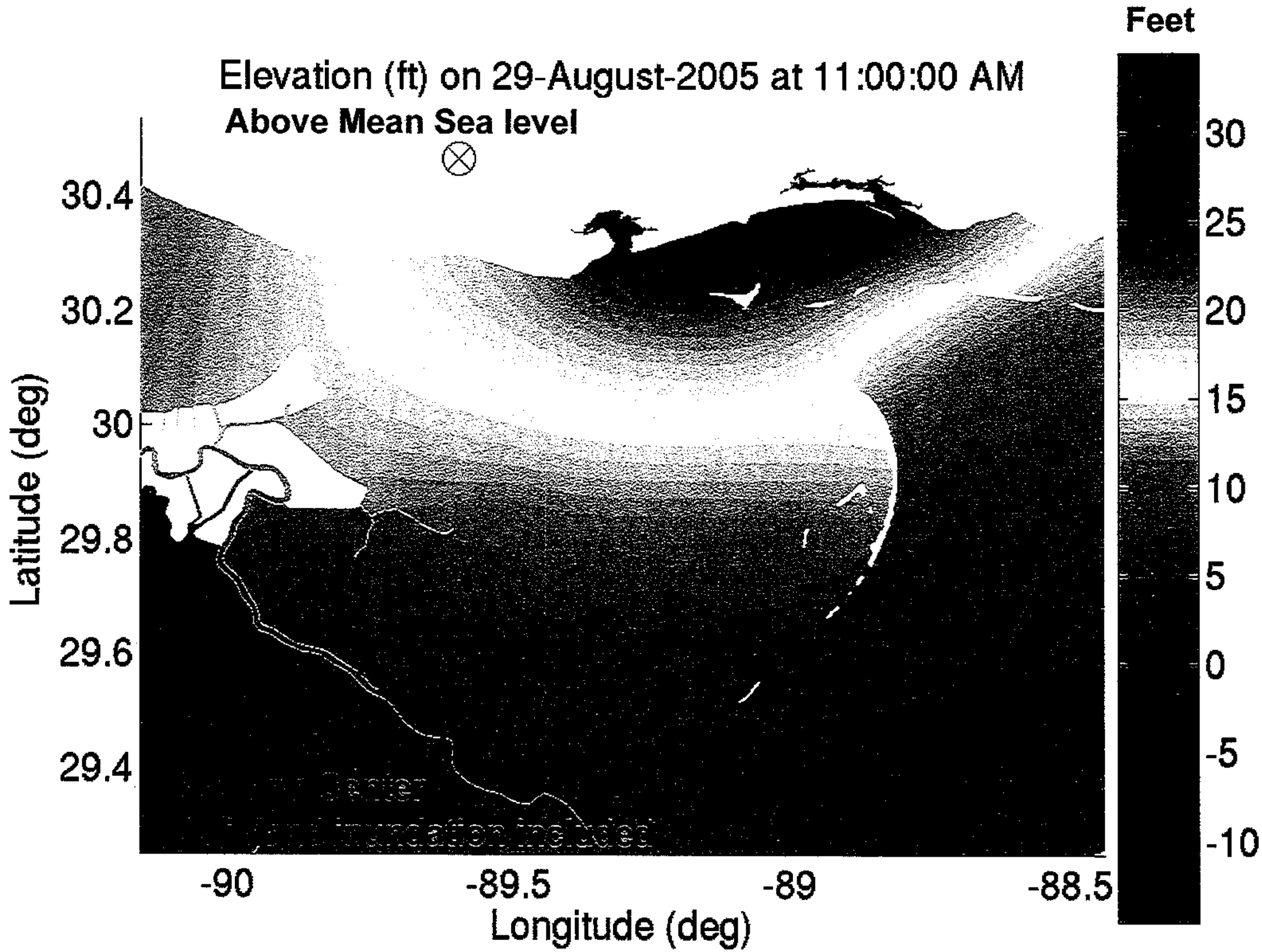
Preliminary Katrina Storm Surge Hindcasts

ADCIRC Computed Tides + Surge

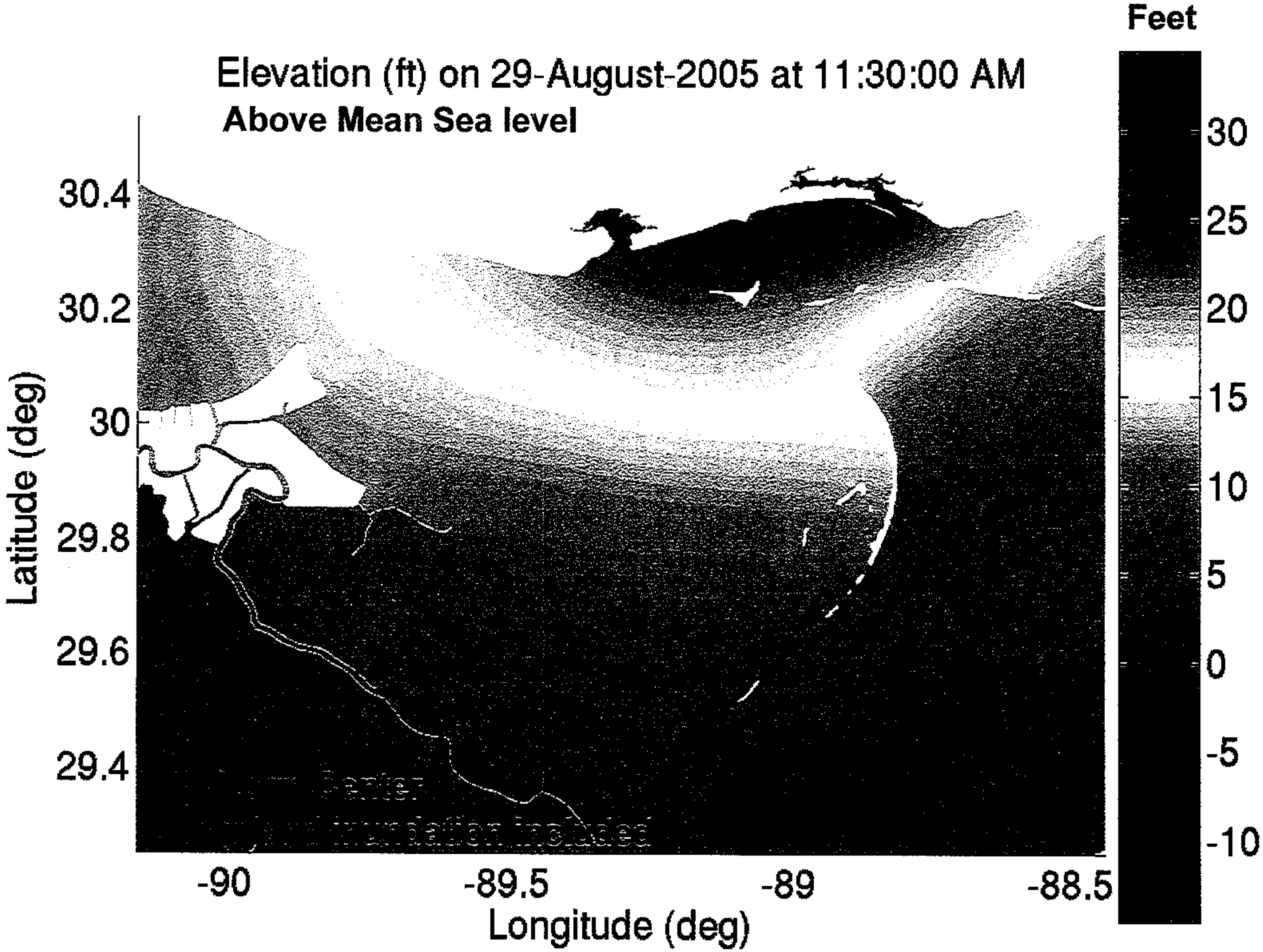


Preliminary Katrina Storm Surge Hindcasts

ADCIRC Computed Tides + Surge

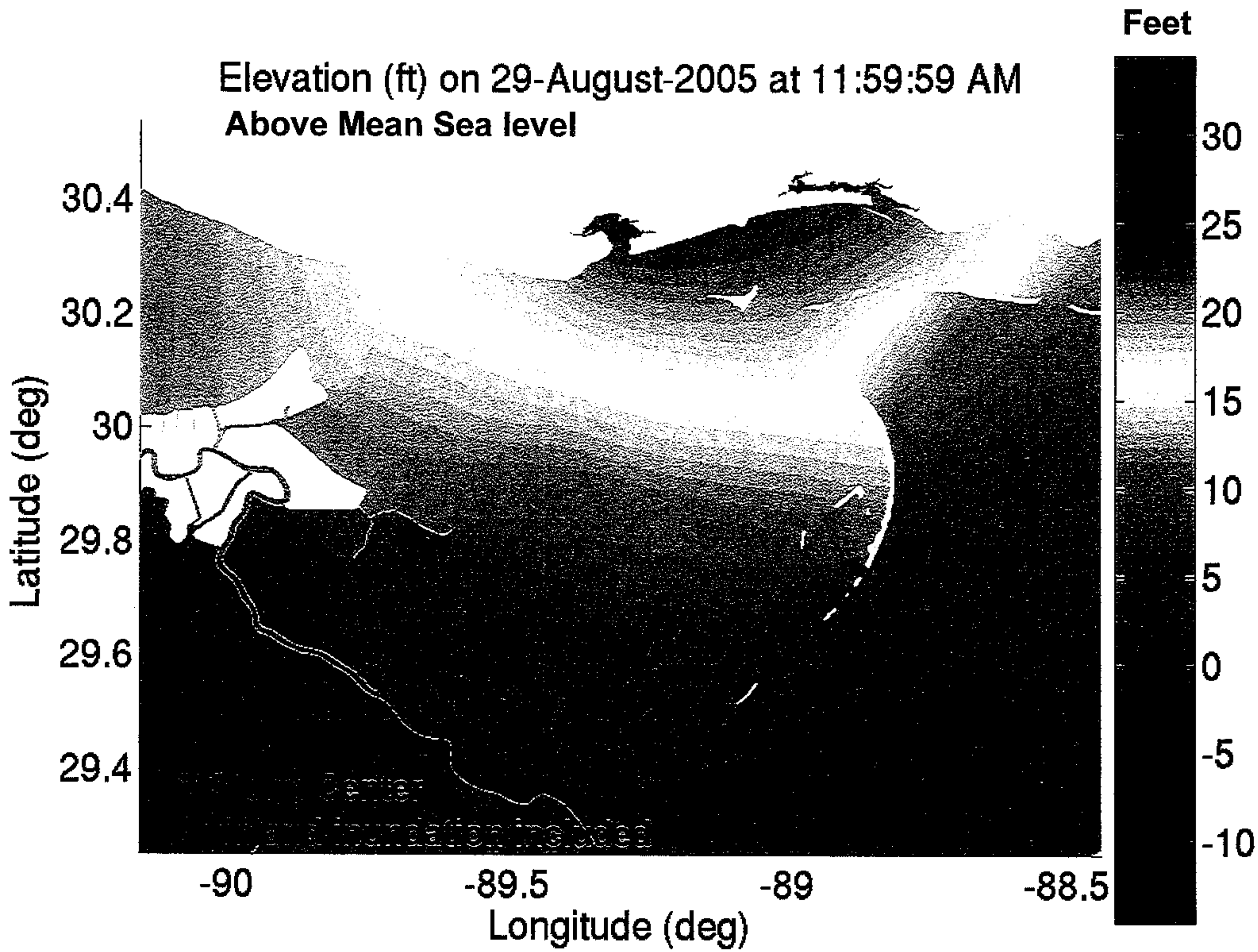


ADCIRC Computed Tides + Surge

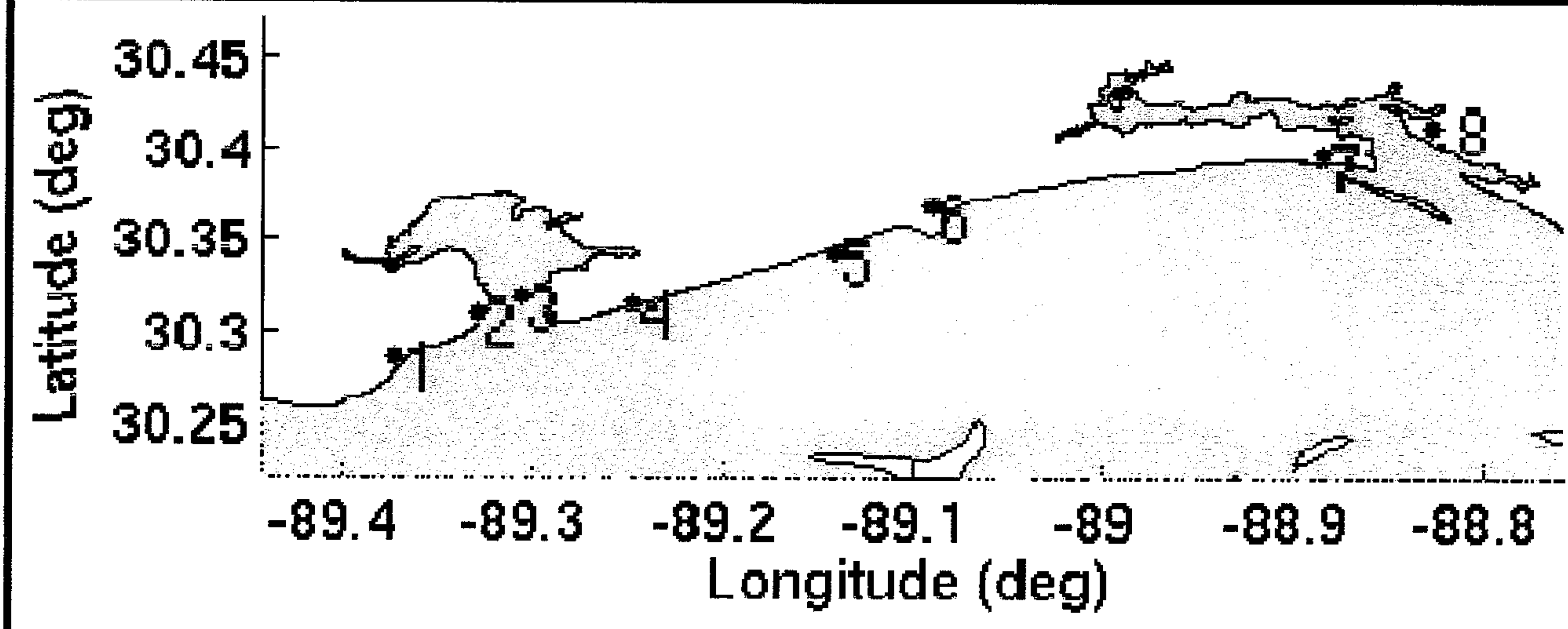


Preliminary Katrina Storm Surge Hindcasts

ADCIRC Computed Tides + Surge

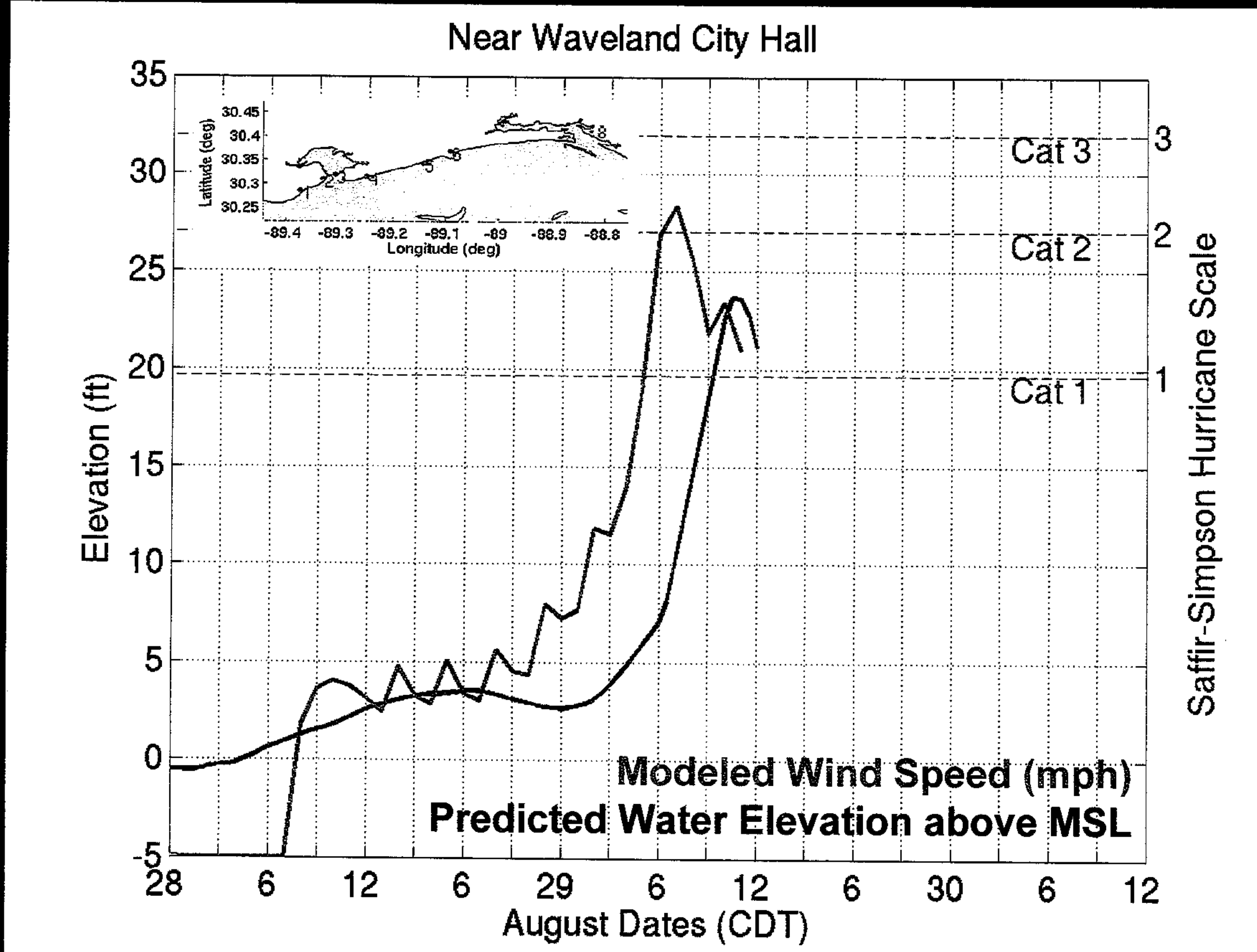


Selected Landmarks



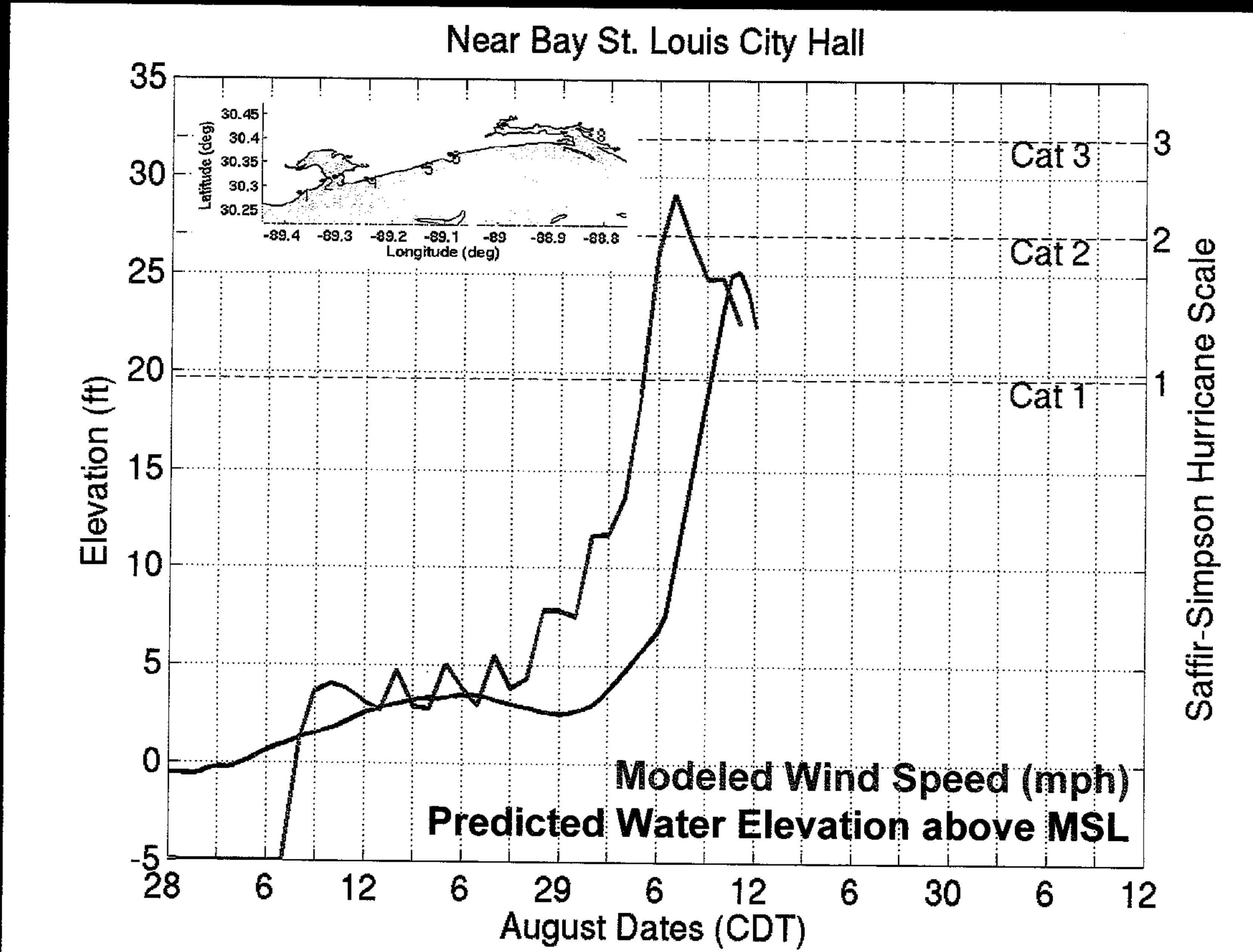
1. Waveland City Hall
2. Bay St. Louis City Hall
3. Bay St. Louis bridge
4. Pass Christian City Hall
5. Long Beach harbor
6. Gulfport City Hall
7. Biloxi City Hall
8. Ocean Springs City Hall

Wind Speed vs. Water Level



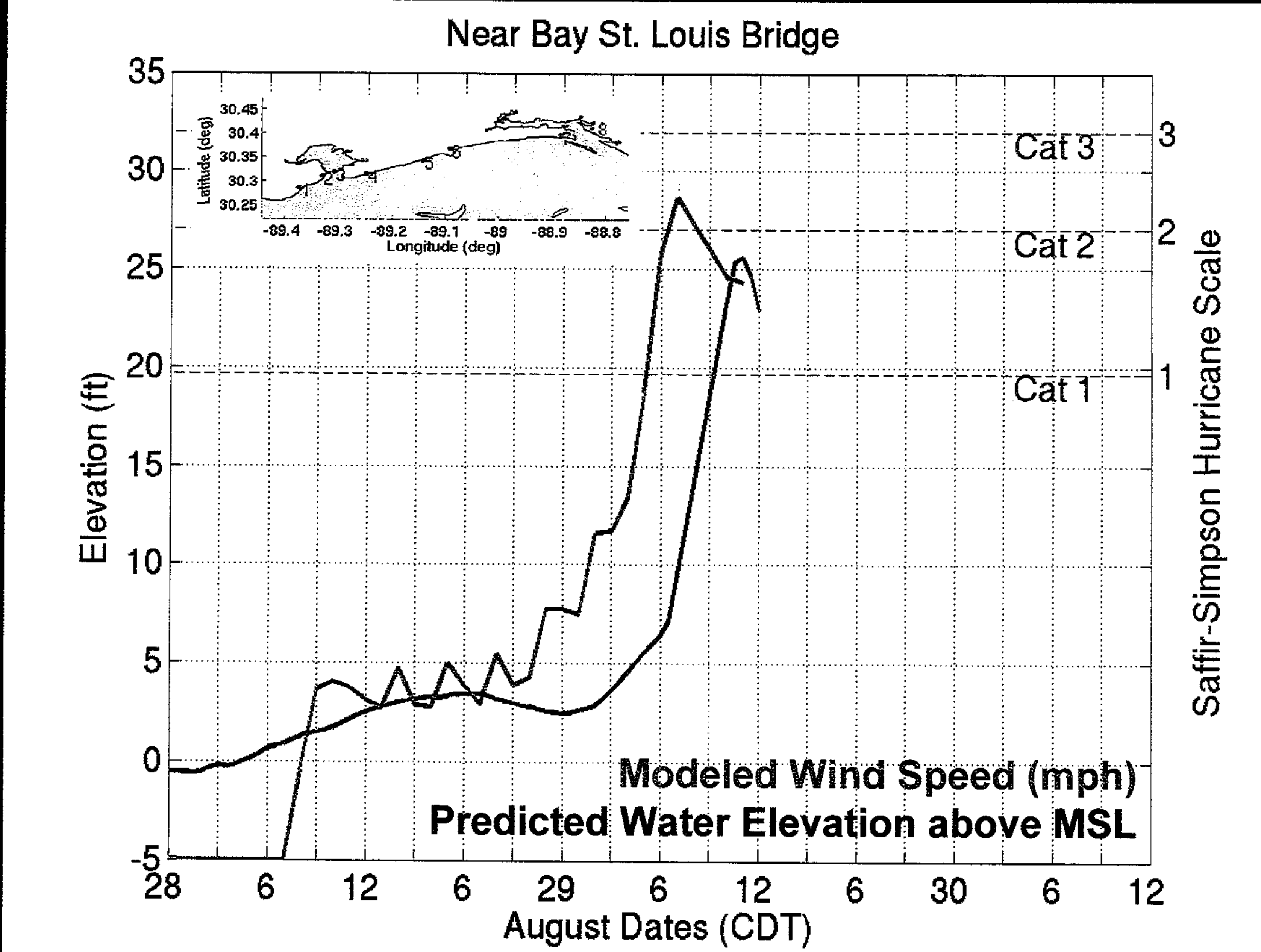
Preliminary Katrina Storm Surge Hindcasts

Wind Speed vs. Water Level

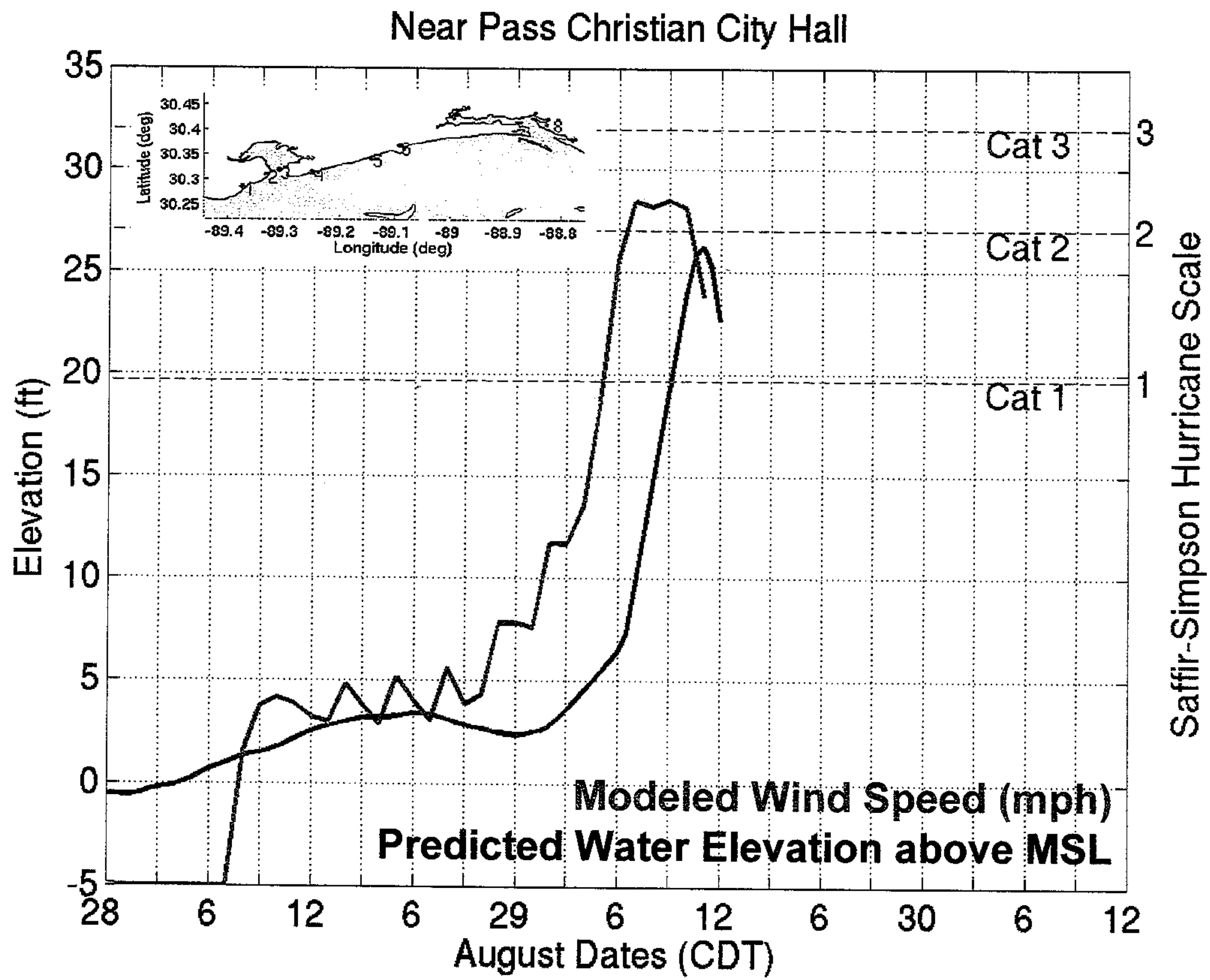


Preliminary Katrina Storm Surge Hindcasts

Wind Speed vs. Water Level

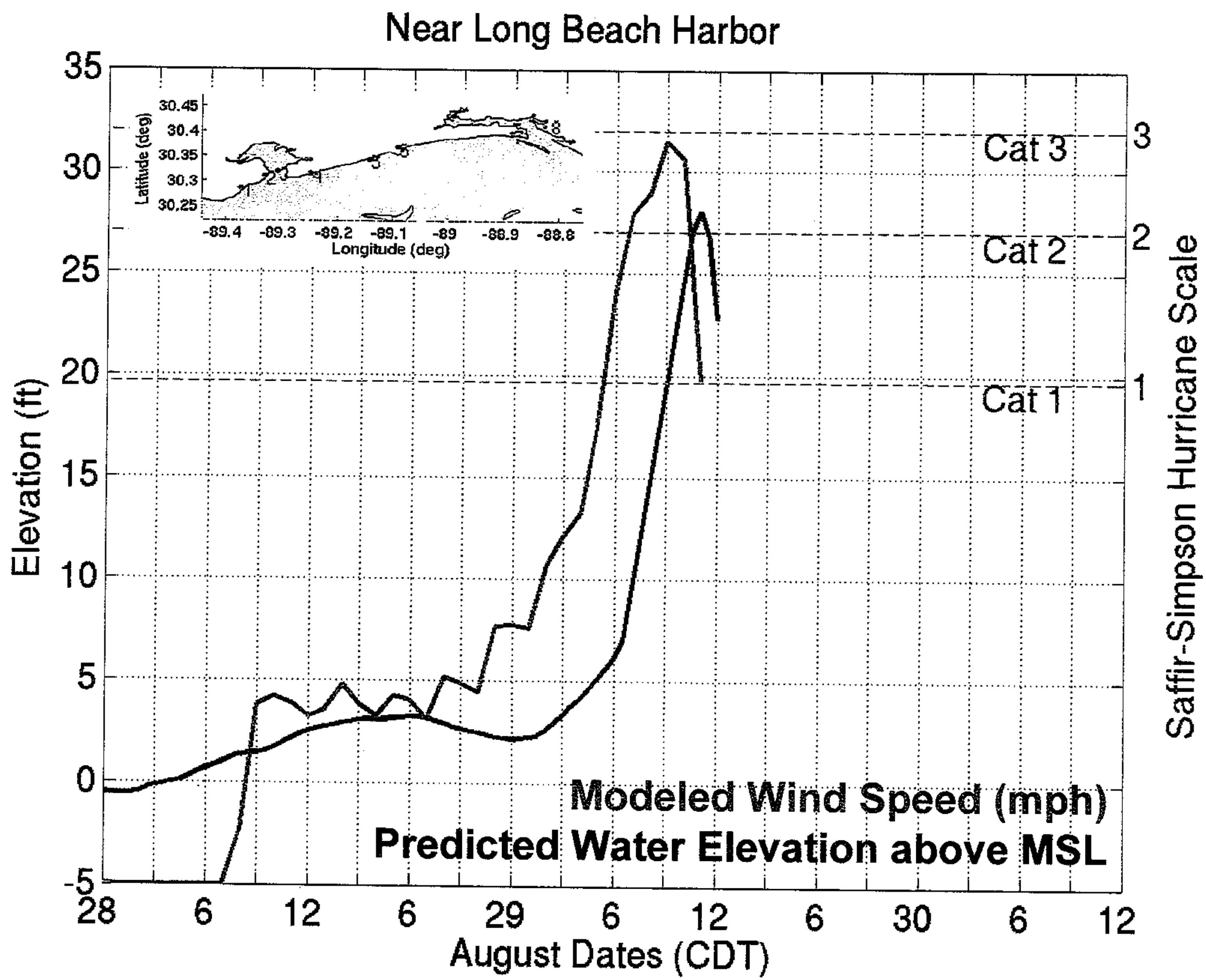


Wind Speed vs. Water Level



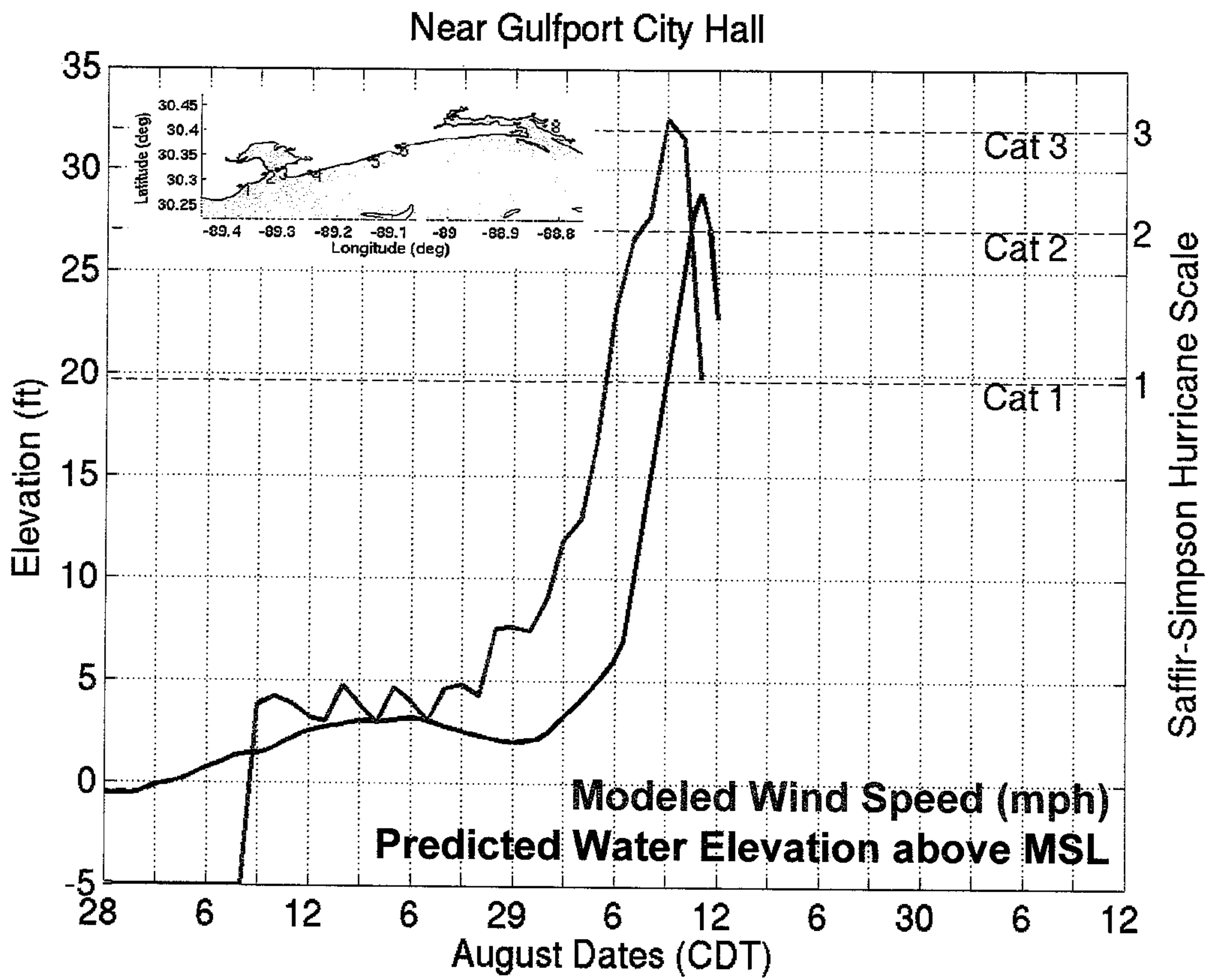
Preliminary Katrina Storm Surge Hindcasts

Wind Speed vs. Water Level



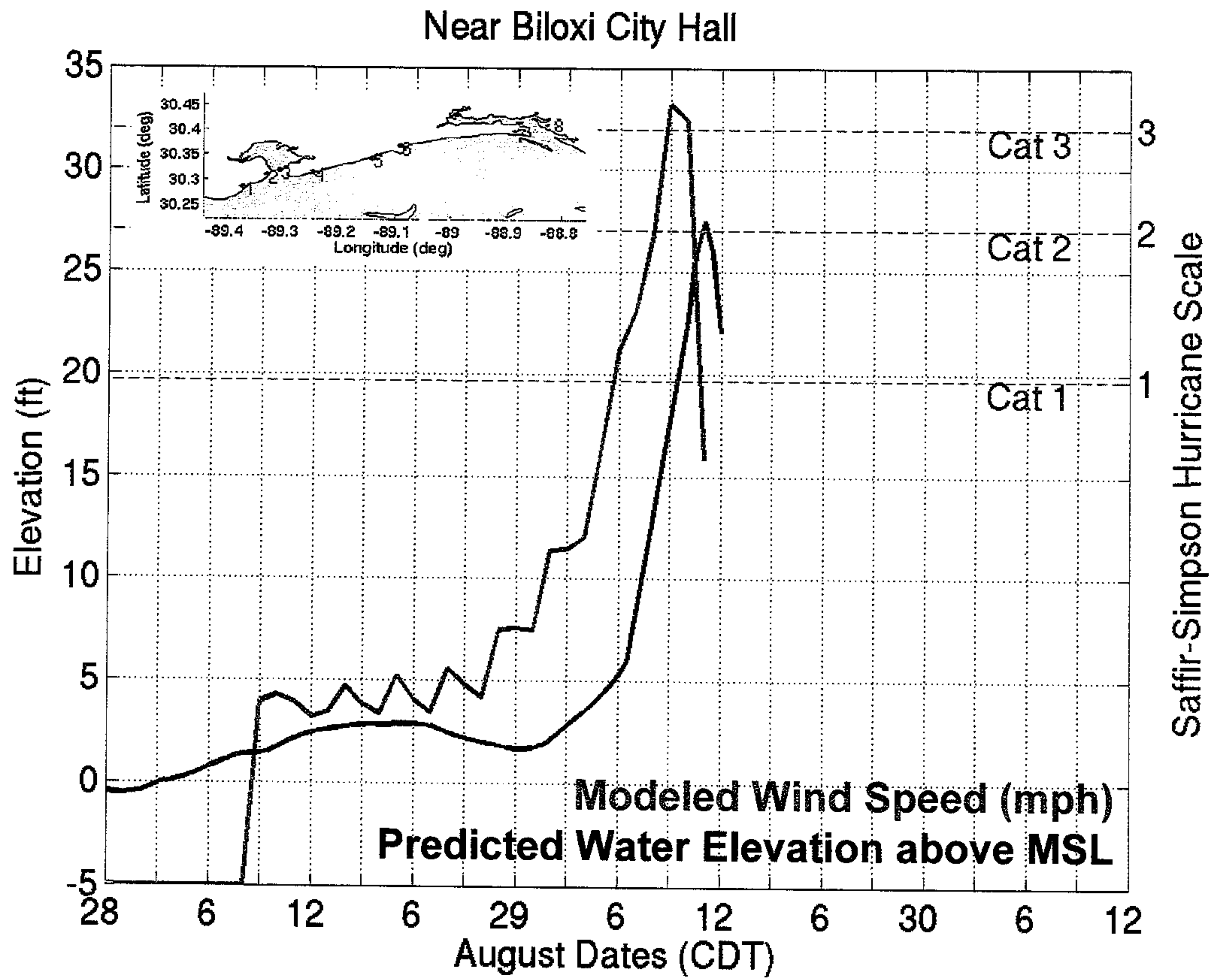
Preliminary Katrina Storm Surge Hindcasts

Wind Speed vs. Water Level

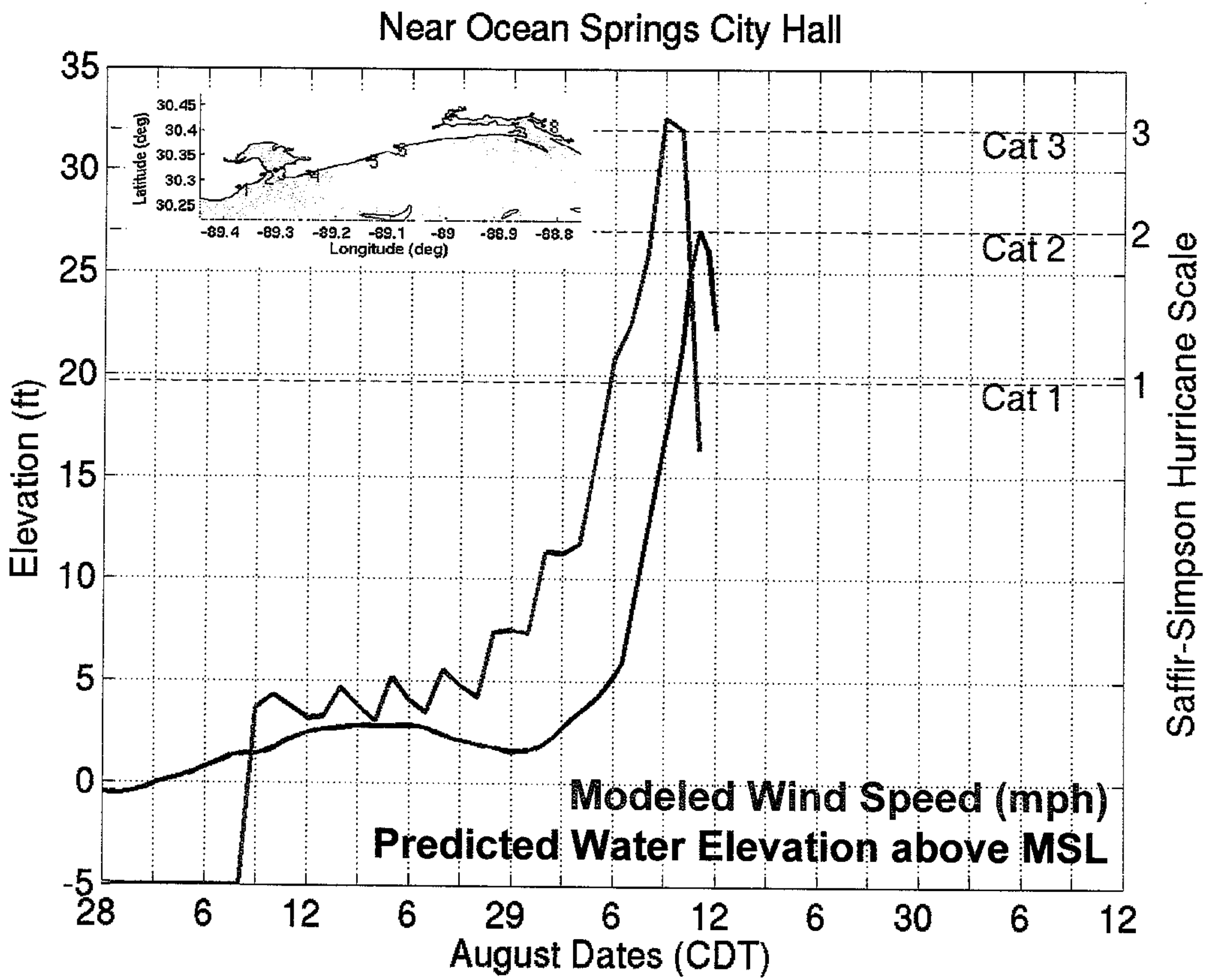


Preliminary Katrina Storm Surge Hindcasts

Wind Speed vs. Water Level



Wind Speed vs. Water Level



Preliminary Katrina Storm Surge Hindcasts

APPENDIX F

Affidavit

State of Mississippi
County of Jackson

My name is George Sholl. I am an adult resident citizen of Jackson County Mississippi and I work as director for the Jackson County Emergency Communications District.

Sunday night before Hurricane Katrina made landfall I was working in the Emergency Operations Center (EOC) located in Pascagoula near the intersections of Convent and Magnolia Streets. I have marked the location of the EOC on the attached map.

The EOC is a 2 story building which had two anemometers and wind direction indicators. These instruments were part of the county's emergency operations center, they are professional type equipment and are accurate to the best of my knowledge. I have no reason to doubt the accuracy of those instruments.

Every so often while I was at the EOC, I observed the indicated wind speed and direction on the instrument. Before midnight wind speeds over 75 mph were indicated. The winds increased through the night and morning. Sometime in the morning after daylight I saw indicated wind speeds of 137 miles per hour generally out of the East. It was after I observed this that sections of the roof blew off of the EOC building and most of us then evacuated to the Courthouse. Some persons who remained in the EOC for a short time after that evacuation and I have heard that they observed indicated wind speeds of 140 mph. The tower blew down approximately 20 minutes after we left and no more readings were possible. The winds continued to increase and from what I saw, I believe that the winds after this must have been over 150 mph.

I cannot state the specific time I saw the indicated wind speed of 137 other than that it was after sun rise and before the tidal surge came into Pascagoula. The sequence of events was in this order: I saw indicated wind speeds of 137 miles per hour, after this roof sections blew off the EOC and we evacuated to the court house and after this the flood water came in over four more feet. When we evacuated the EOC, the flood water was just coming in.

I remember watching from the Courthouse as the water gradually came in and rose over four feet above the area I had walked through. There was never anything like a "tidal wave". I remember that as the water rose it flooded cars parked around us and car alarms went off and car trunks came open on their own. Understand that the maximum flood water level was marked on the side of the EOC building steps and that point was surveyed and found to be 16 feet above sea level.

The facts as stated in this affidavit are true and correct based upon my personal observations and knowledge unless otherwise stated.

George Sholl

George Sholl

18 NOV 05

Date

Personally appeared before me the undersigned authority in and for Jackson County, George Shoell who after first being sworn did state on oath that the facts and contained in this affidavit were true and correct. This the 18th day of November, 2005.

Patricia B. Byars

Notary Public

PATRICIA B. BYARS NOTARY PUBLIC JACKSON COUNTY, MS

MISSISSIPPI STATEWIDE NOTARY PUBLIC
MY COMMISSION EXPIRES MAY 1, 2006.

APPENDIX G

APPENDIX G

DRAKE RESIDENCE RECONSTRUCTION ESTIMATE

95 LaBRANCHE AVENUE OCEAN SPRINGS, MISSISSIPPI

FROM

DAMAGES FROM HURRICANE KATRINA

I. Rebuild complete house using existing foundations and slab with addition of hurricane anchors, straps and tie-downs from foundations to roof structure.

Base cost per R. S. Means 2005 Residential Cost Data for Wood Frame/Brick Veneer - Luxury – 2 story construction (Reuse ground floor concrete slab for garage area)

Base Cost w/Basement	=	$ 117.80 per square foot
Upgrade Ceiling Finish	=	(+) 0.40 per square foot
Add for Heat Pump	=	(+) 2.29 per square foot
Total Base Cost	=	$ 120.49 per square foot
Heated & Cooled Living Area	=	5,512 S.F

Base Cost:

5,512 SF @ $120.49	.=	$664,141

Upgrades & Adjustments:

Chimney & Fireplaces	=	$ 18,130
Upgrade Kitchen Cabinets	=	$ 35,000
Add full baths: 4 @ $8858	=	$ 35,432
Upgrade bath vanities: 5 @ $5,000	=	$ 25,000
Appliances	=	$ 35,000
Covered Porches:		
335 S.F. @ $62.85	=	$ 21,055
Finished Basement/Garage		
2,410.8 S.F. @ $50.00	=	$120,500

Patio: 168 S.F @ $35.00	=	$ 5,880
Reconstruct Lawn & Landscaping Allow	=	$ 50,000

TOTAL ESTIMATED RECONSTRUCTION TOTAL = $1,001,138

2. Alternative Cost Estimate for cost of interior heated and cooled living area.

The house was a luxury home with exquisite appointments throughout and the $120.49 per square foot estimate shown in Means would not be nearly enough to rebuild this luxurious home. It is commonly reported on the Gulf Coast that $140.00 to $175.00 per square foot costs are being quoted by contractors at the present time for reconstruction of custom homes. Since this house was such a luxuriously constructed house, I believe that a reasonable base cost estimate for reproducing the quality of construction of this house could be as much as $175.00 per square foot at the present time. Therefore, I modify the estimate above based on the R. S. Means unit cost as follows.

Heated and Cooled Living Area = 5,512 S.F

Estimated Reconstruction Cost:

5,512 S.F. @ $175.00 = $964,600

Increase in estimated cost by alternative pricing:

$964,600 – 664,141 = $300,459

Alternative Total Cost Estimate

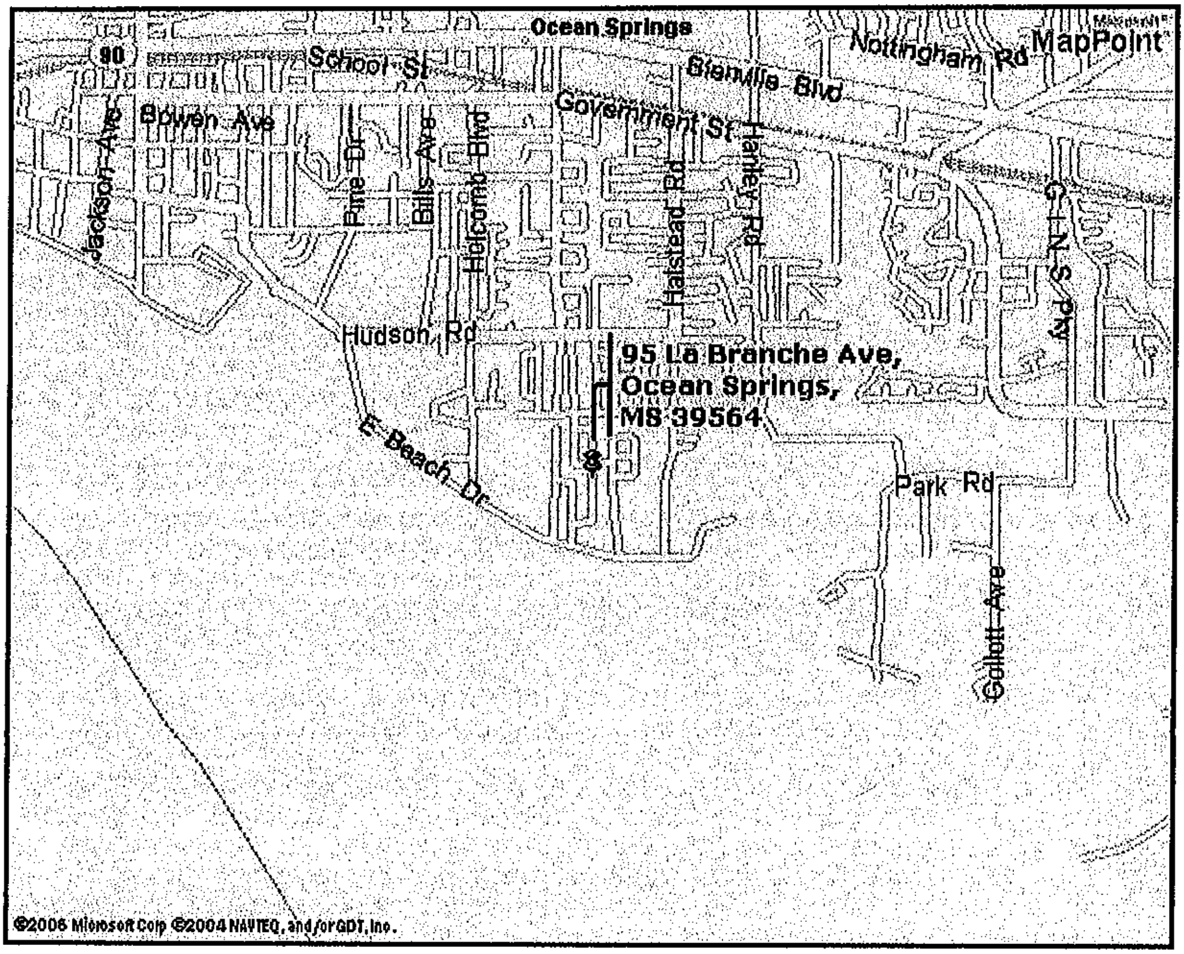
$1,001,138 + $300,459 = $1,301,597

APPENDIX H

msn Maps & Directions

Featuring Microsoft® MapPoint® Technology

95 La Branche Ave, Ocean Springs, MS 39564



Your right to use maps and routes generated on the MSN service is subject at all times to the MSN Terms of Use.
Data credits, copyright, and disclaimer.

APPENDIX I

David Beale
PO Box 675
Ocean Springs, MS 39566
228-323-2655

To Whom It May Concern:

This is to confirm that I was present in the home at 106 San Souci Ave., Ocean Springs, Mississippi when Hurricane Katrina tore the structure apart. It is a fact that while water came in the bottom of the home, the wind took off the south end of the roof and the patio roof on the west side of the home. I had to evacuate the home to the roof of a neighboring home and am not aware of the further damage to the home as it was happening. I did see other roofs in the neighborhood such as the residence of Jerry Platt at 102 San Souci Ave be lifted by the wind before the water reached it. It is my opinion that the devastation to these homes was the result of a combination of wind then water.

Regards,

David A. Beale

David Beale

KEITH SAWYER
My Comm. Exp. 01/13/08
Notary I.D. 1028278
DD281050

Keith Sawyer
04NOV05

PERSONALLY KNOWN